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PART II.

EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WAR DEPARTMENT.

ROUTE NEAR THE THIRTY-FIFTH PARALLEL, UNDER THE COMMAND OF LIEUT. A. W. WHIPPLE, TOPOGRAPHICAL ENGINEERS, IN 1853 AND 1854.

REPORT

ON

THE TOPOGRAPHICAL FEATURES

AND

CHARACTER OF THE COUNTRY.

WASHINGTON, D. C.
1856.

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General map from Rio del Norte to the Pacific ocean, upon a scale of one inch to 15 miles.

Profile of a route for the Pacific railroad, from Fort Smith to Martinez, near San Francisco.

GENERAL SKETCH OF THE ROUTE.

Our operations have been confined to a belt of country bordering upon the parallel of 35° north latitude. The conformation of this region is such as to afford some peculiar advantages for the construction of a national railroad. There are many water-courses passing through it, and valleys extend in the desired direction over a great portion of the distance between the Mississippi river and the Pacific ocean. This route would accommodate the eastern trade which centres at Vicksburg, Memphis, and St. Louis; and the railroads which are contemplated westward from those cities, through the States of Louisiana, Arkansas, and Missouri, might well converge and unite upon the Canadian.

From the eastern border of the Choctaw territory to the head of Pajarito creek, about seven hundred miles, our route is near the valley of the Canadian. Beyond, to Rio Pecos, (nearly forty miles,) it passes a ridge which extends northwardly from the Llano Estacado and divides the waters of the Mississippi from those of Rio del Norte. After crossing the Pecos, threading Cañon Blanco, and traversing the high mesa which breaks the continuity of the Rocky mountains, this line unites with the valley of Rio Galisteo, and strikes the Rio del Norte near San Felipe; or, by a shorter route, from the lagunas near the head of Cañon Blanco, proceeds by the way of San Antonio Pass to the narrows of Rio Grande, at the Pueblo of Isleta.

Having crossed the Rio del Norte, and also the Puerco, we ascend by Rio San José and the broad opening in which it takes its rise, to a low point upon the crest of the Sierra Madre; the range which divides the waters flowing towards the Gulf of Mexico from those emptying into the Pacific. From this summit, the valley of Rio Puerco of the west leads to Colorado Chiquito, (Flax river,) down which we proceed to the great bend towards the northwest. Then, by a pass south of the San Francisco mountains, we enter a well-wooded region where springs feed the head branches of Rio Verde. Continuing westward, we cross various small rivulets, and, edging along the banks of Pueblo creek, ascend to Aztec Pass. Thence to the Mojave villages two routes are noticed; one, following the valleys of Williams' river* and Rio Colorado; the other, a shorter line in nearly a direct course westward from Aztec Pass, via White Cliff creek and a gap which separates the Cerbat range from the Blue Ridge or Hamook-häbî mountains, to the Colorado above the cañon of "The Needles," near Camp 132. Leaving Rio Colorado at the Mojave villages, we pass the Paiute mountain, with steep but regular slopes, to Soda lake, and a few miles beyond, upon the flowing waters of Mojave river, unite with the survey of Lieutenant Williamson. As that officer is now understood to have been successful in his explorations through one of the Tulare passes to San Francisco, we need but refer to his report for a description of the remainder of this route to the Pacific.

The line will now be divided into sections, and the topographical features of the country given somewhat in detail.

* Heretofore called "Bill Williams' Fork." The Mojave or Cuchan name of this stream is "Häwîl-hamook," meaning *third river*.

SECTION I.

From the Mississippi River to Fort Smith.

The legislature of Arkansas having already taken the initiative with regard to the construction of a railway through the State, from the Mississippi river to Fort Smith, no special examinations were required of us within those limits. It may, however, be remarked that, from the general nature of the country and the vicinity of navigable rivers, the grades would necessarily be light, and materials for the construction of a road easily obtained.

The height of Little Rock was found by observations to be 351 feet above the level of the sea. Napoleon is 142 feet above tide-water, and Memphis, by estimate, 54 feet higher, making 196 feet. This would allow the difference of level between Memphis and Little Rock to be 155 feet; and the distance being about 155 miles, the mean ascent would be one foot per mile. From information that seems reliable, it appears that, from the point opposite Memphis to the river St. Francis, thirty-nine miles, there is an extensive marsh subject to overflow, rendering an embankment necessary for the road that crosses it. To avoid this, although probably not a very serious obstacle, Helena has been suggested as the terminus of the proposed railway from Fort Smith to the Mississippi. From the St. Francis to Little Rock, 116 miles, the country is said to be undulating, with woodlands and prairies favorable for the location of a railway.

Between Little Rock and Fort Smith there are two ranges of mountains, called the La Fourche and Petit Jean. They rise abruptly from the river, with peaks 1,000 feet high, and are said to extend southwest some thirty miles. It is believed that the country beyond is favorable for a railroad, which would thus avoid a large bend of the river valley.

The banks of the Arkansas are covered with excellent timber—ash, elm, black walnut, pecan, and various kinds of oaks. Above Little Rock the lower carboniferous formation commences, soon passing into coal measures. Coal outcrops at various points in the neighborhood of the river; it is bituminous, of good quality, and easily obtained. Considerable use is made of it for fuel, and as population increases, and the superabundance of wood is diminished, the value of this source of wealth will be more highly appreciated. The State abounds in mineral wealth. Its stores of iron are believed to be inexhaustible. Lead, copper, and silver are said to be found in considerable quantities. Quarries of roofing slate, near the river, furnish a large supply of that material for the markets of St. Louis and Cincinnati.

Fort Smith is situated upon the right bank of the Arkansas river, just below the junction of the Poteau. The military post is near the fork, and within the Choctaw territory. The town, or city, commences a few hundred yards below, and is within the limits of the State. The position is upon a ridge of dark micaceous sandstone, rising about sixty feet above the river. The back country is composed of wooded hills and high prairies. Some thirty or forty miles distant, south, are seen the summits of Sugar-Loaf and Poteau mountains, two thousand feet above the river.

Numerous barometric observations at Fort Smith made its altitude four hundred and sixty-eight feet above the sea. Supposing the distance from Little Rock to be one hundred and sixty miles by land, and the elevation, as observed, one hundred and seventeen feet, the mean grade would be less than a foot per mile.

SECTION II.

From Fort Smith to the head of Pajarito Creek, seven hundred and two miles.

The Canadian river and the branch above mentioned may be considered as occupying the same general valley, the course of which is nearly west for the distance specified.

The mean inclination of the Canadian is nine feet per mile, from the junction of Tucumcari creek to its entrance to the Arkansas, affording light grades, without expensive excavations or embankments. Few large bridges would be required, because most of the tributaries sink as they approach the great valley. The trail upon which our profile was made, in order to avoid some of the principal bends of the river, is generally favorable for the location of a railway. Some of the valleys traversed, particularly those of Walnut creek, Deer creek, and the affluents to the False Washita, contain better timber than is found upon the banks of the Canadian, in the same meridians. There is, upon this section, plenty of sandstone, quicklime, and gypsum. Upon the eastern part, extensive beds of coal and large forests of trees afford fuel and timber in abundance. The Cross Timbers extend to the meridian of 99° 11′ west from Greenwich; and the wooded branches of the False Washita would afford materials for bridges and railroad-ties fifty or sixty miles beyond. Thence, to the end of the section, from three and a half to four degrees further west, good timber is scarce; yet large cotton-wood trees grow in the valleys, and the hill-slopes are covered with thick groves of cedars which afford excellent fuel. Lieutenant Abert reports the existence of "an abundance of timber" a short distance above the mouth of Tucumcari creek. Hence, the supply for the construction of a road in this vicinity might be obtained from that region, or from the Cross Timbers. Upon this section, the labor of graduation could not much exceed that required in the valley of the Ohio. The expense of bridging will be small. In cutting off the bends of streams, our trail crossed a few barren spots; but the valleys throughout this section may be cultivated. The eastern portion is remarkably fertile. Throughout the extent of the Canadian valley, the precipitation of moisture is evidently greater than occurs elsewhere, north or south, within the arid region that lies east of the Rocky mountains. Springs and streams are numerous, and common wells, or short aqueducts, would furnish sufficient water at those points where railroad stations would be required.

From a general view of this section, we will pass to the consideration of some of its topographical details, taken from the field-notes and journals of the expedition.

From station 1, near the flag-staff at Fort Smith, to the ferry of the Poteau, the distance southwest is nine hundred yards, and the descent fifty-two feet. The width of the stream at that point is two hundred and thirty-five feet. The water is somewhat turbid and apparently deep, being backed up from the Arkansas with which it unites a few hundred yards below. The right bank of the Poteau is formed by a nearly precipitous ledge of slaty rock, from twenty-five to thirty feet high. The left bank is generally about eight feet above the water's edge, but during freshets is overflown. Better points for bridging occur above the ferry. That considered the most favorable is at the ford, where the bottom is of rock, and bluff-banks at nearly equal heights line both sides. A span from thirty to fifty feet is believed to be sufficient; and building materials may be found in the vicinity.

From the ferry, before noticed, the road crosses a low bottom land, extending from the Arkansas on the right to the Poteau on the left. This is covered with forest trees of various kinds, and a thick undergrowth. Eight miles distant from Fort Smith there is a Choctaw set-

tlement with cultivated fields. A mile or two beyond, the road ascends to a ridge about sixty feet above the river. Here is a farm-house, near which was formed our Camp 1. It is nearly intermediate between the Poteau and the Arkansas. The slopes are covered with oak timber, suitable for railroad ties. The soil is good for tillage, and both the smooth prairies and the ravines afford pasture. There is no need for the railroad line to ascend this ridge. Either base of it could be followed, but that by the Poteau is preferred.

From Camp 1 to Scullyville, the road continues upon the high lands, crossing a prairie and several ravines with descents and ascents averaging about fifty feet. The country is well timbered with white-oak, post-oak, and blackjack. Several farm-houses and cultivated fields were passed. The route proposed for the railroad follows the course of the Poteau upon the left.

From Scullyville the general character of the country near the road is unchanged to Camp 7; consisting of isolated prairies and wooded hills, with small creeks and rills among the ravines. A few miles south of the road is found a more level country of prairie character, with a drainage to the Poteau. Upon this is the railroad line, proceeding from a point south of Scullyville to a densely timbered valley between Piney Ridge and the Sans Bois mountains. Near the western part of this valley we reach the head-waters of a branch of the Poteau, cross an almost inappreciable summit, and find other prairies leading to Sans Bois river. This river is seventy feet wide, and would require a bridge with a span of seventy-five feet. The distance from Fort Smith is fifty-four miles; the grades quite easy, the maximum being forty feet per mile, with little labor for excavation or embankment. There are few ravines which would require bridging. The route now follows the valley, ascending the right bank of the Sans Bois river for a distance of sixteen miles, then crossing the stream, which is seventy feet wide, and keeping near the left bank to its head-waters. From that point a low divide is passed, and we reach La Honda, which a short distance below empties into Gaines's creek.

In the vicinity of Sans Bois creek there are forests of great extent, abounding in oak, hickory, and pecan timber. Upon the hills, sandstone is found suitable for the purposes of construction. The wide bottom-lands, through which numerous tributaries of the South Fork of the Canadian have worn deep channels, possess a rich alluvium, covered with timber of remarkable size and beauty. In this vicinity there are Chickasaw settlements, with numerous cultivated fields.

Gaines's creek is a clear stream twenty feet wide, with banks in some places twenty feet in height. For a bridge, a span of fifty feet would be required. Thence, the country is undulating for fourteen miles to Coal creek. This stream, which is ninety-five feet wide at the crossing, is another of the tributaries of the South Fork. Its name is derived from the great quantity of coal found in the vicinity. In several places the coal-bearing strata crop out above the surface. They appear also upon Sans Bois creek and at other points between Fort Smith and this place. Ordinary wells in this region, from forty to fifty feet deep, frequently discover beds of coal two to three feet thick. Besides bituminous coal, sufficient for the uses of a railway and for exportation, this formation contains sandstones and limestones excellent for the construction of bridges and viaducts.

The valley of Coal creek, although intersected by several ravines and spurs of rocky hills, may be followed to the head of one of its branches near a low divide, south of the Shawnee hills, which separates it from Boggy river. This range of hills is rough and steep, even for the wagon road which crosses it; but as it trends westwardly, it may be turned by passing the dividing ridge between Coal creek and the Boggy, about eight miles south of Shawnee village. The ascent from Coal creek to the summit is by a broad prairie; thence to Camp 17 there is a forest, intersected by narrow ravines and intervening hills across which easy passages are found. The grades are from twenty to thirty feet per mile.

Upon entering the wide and nearly level basin, fertilized by numerous small tributaries of Boggy river, the woods become less dense, and soon give place to open prairies of considerable extent. Upon the north is a ridge of wooded hills, extending from the Canadian towards the southwest, so as to include Delaware Mount. There are several passes through this range, two

of which open to an extensive prairie, nearly level, leading to Beaverstown. A route is indicated also west-southwest, about eight miles, to the valley of Washita river; which, as laid down from Captain Marcy's survey, would afford a good location to its source near the Canadian. The line which is developed upon the profile keeps near the road, passing Beaverstown, and crossing the almost inappreciable crest of the divide at Camp 23. Beyond, it is easy to pass into the valley of the Washita, or follow in the vicinity of our trail, threading the fertile basins watered by Walnut and Deer creeks, edging the forest of Cross Timbers to Rock Mary, and thence crossing a bleak prairie to Gypsum creek, near its confluence with the Washita.

Delaware ridge is the boundary between the carboniferous group and the new red sandstone, or Trias; and the topographical features east and west are also different. Thence to Camp 20, the country is wooded and somewhat hilly, being intersected by Topofki creek and other affluents of the Canadian. The streams are small, with gravelly beds—the largest thirty feet in width. The hills passed are from fifty to seventy-five feet in height above their base; they gradually diminish and disappear in the direction towards the Canadian. From Camp 20 to Beaverstown, we crossed a portion of the woodless plain referred to. It is, however, intersected by several ravines, with a border of trees variegating the landscape. Beyond, the country acquires in a great degree the distinctive characters of the western prairie. The surface is nearly level, and trees scarce. Opposite Camp 22, the Canadian makes a large bend towards the north, and our trail, instead of following it, kept near the summit of the prairie slopes, which separates the waters of the Canadian from the tributaries of Red river. At Camp 23, near the eastern edge of the forest of Cross Timbers, there is an Indian trail leading southwest, along the borders of a small creek, to the Washita river. This is a favorable entrance to the valley of that stream, which would probably afford a favorable location for a railroad to its source. To avoid penetrating the dense growth of post-oak and blackjack, of which this forest consists, the wagon road skirted the northern edge of it, crossing numerous flowing streams tributary to Walnut creek. The soil of their valleys is a rich loam, producing rank grass, and large oak and hickory trees. At the head of Walnut creek, we again found ourselves upon a broad prairie, where gypsum appeared upon the surface. The Cross Timbers here recede several miles towards the south. The grassy plains, somewhat cut up by ravines, extend to the well-wooded valley of Deer creek. This is a clear and rapid stream, flowing to the Canadian. Where forded, it was two and a half feet deep and six feet wide. Its waters irrigate a considerable extent of country, admirably adapted to agriculture. Leaving Deer creek, we again crossed a series of plains intersected by small arroyos; the Cross Timbers being visible upon our left until we reached "Rock Mary," one of the so-called natural mounds, which are from seventy-five to one hundred feet in height. These are horizontally stratified, and appear to be isolated remnants of the mesa formation which once covered this region. Beyond, the surface is level, sandy, and covered with extensive beds of gypsum of the best quality. For about ten miles, no streams or springs were passed. The aspect of the country is barren and desolate. It could be avoided by descending from Camp 28 into the valley of the Canadian, or by following the Washita, as proposed, from Camp 23. Near Camp 30, we crossed Gypsum creek, an affluent to the Washita, flowing south through bluff banks cut from an alluvial valley. It would require a bridge about 150 feet in length. The stream is well wooded with oaks and elms, excellent for timber; the current is rapid; the water is slightly brackish, but deep, containing an abundance of fishes.

At short distances beyond, are Bear creek and Elm creek, both covered with timber, the latter twelve feet wide and three and a half feet deep. Then appears the main valley of the Washita, a beautiful stream, traceable for a long distance, from the west-northwest towards the east-southeast, by the belt of timber which borders it. The valley is wide and fertile. It receives numerous tributaries from the north, divided by banks of red clay and gravel. As far as visible, it affords a good location for a railway. Probably it might be followed to its junction with Red river, and thence, via Shreveport, communication would be established with all the southern commercial cities.

The ridge which divides the waters of the Canadian from those of the Washita, maintains a nearly uniform height throughout its whole extent; but it is much contracted in width near the head branches of the latter stream. The arroyos, therefore, which lead from it are washed into gullies, and have steep declivities. For a railroad, it might be preferable to ascend in a northwest course along the southern slope of this ridge, cross the elevated mesa south of the Antelope hills, and enter the Canadian valley at Grape creek. Our trail followed a northward course towards the Canadian, crossing various tributaries of the Washita. Comet creek flows in a cañon, with banks about thirty feet high, requiring, near its mouth, a heavy embankment and a bridge from fifty to one hundred feet in length. Thence to Camp 33, the appearance of the country remains nearly the same as has been described; a succession of spurs and intervening rivulets, which unite a short distance below, in the valley of the Washita. Marcou creek, Oak creek, Buffalo creek, and some others, are flowing rivulets, with banks covered with timber, which would suffice for the necessary bridges. The numerous valleys are adapted to agriculture, and the high lands to grazing. Buffalo-grass appears near the head-waters of the Washita. Other prairie grasses are abundant eastward.

The first of the engineering difficulties encountered upon this route is in crossing the narrow ridge which divides the head-waters of the Washita from the Canadian. From the summit, gullies have been washed from the red clay banks so as to render considerable excavation and embankment necessary for a side location upon the ridge. In order to avoid the gullies, two modes are proposed. The first—following the main valley of the Washita to its head, edging along the southern slopes of the mesa to its top, near the Antelope hills, and then crossing into Grape creek—has already been referred to; the other, is to ascend a branch of the Washita, and cut through the crest to a corresponding ravine which leads to the Canadian.* The distance is short, but the excavation would be considerable. According to the profile a maximum grade of 75.6 feet per mile would be required for a short distance.

The following brief extracts from the field-notes will give more in detail the character of this dividing ridge, and other difficult portions of the route immediately on the line of survey.

The creek at Camp 33 is well timbered with oak and some cotton-wood. From the camp back to where the road crosses the river is a valley, the general width of which is about half a mile. The stream is very crooked. There is a low range of hills to the left. From station 19† the ground appears more favorable upon the left of the trail, until, passing Camp 33, we reach station 3. Grade, from station 3 to station 12, not more than fifty feet per mile. Station 7 is upon the table-land, and the ascent to it, from Camp 33, is gradual. Two creeks, branches of Buffalo creek, pass through stations 11 and 12, and join below. Both are dry, but contain large alamos and oaks. Station 15 is on the top of a ridge. The hill is considerably cut up into gullies; the soil is composed of red clay and sand; good water is found at Alamo spring. Beyond, the surface is prairie; and to station 23 there are few obstructions. Between station 23 and Camp 34 is the dividing ridge which separates the waters of the Canadian from those of the Washita. It can be passed by running from station 22 or station 23, slightly to the right of station 27, which is upon the summit; and thence entering a ravine which leads to the Canadian, about two miles distant. To obtain a grade of sixty feet per mile, a cutting of fifty feet would be required.

Near station 26 there are a few dwarf oaks. Captain Marcy's trail, which, avoiding the valley of the Washita, kept the dividing ridge near the Canadian, passes through station 27 and to the

* From this point of the Canadian, it is believed that a railroad might easily be constructed, in nearly a direct line, to Springfield, Missouri, there to unite with the railroad from St. Louis. The gypsum formation extends for some distance north of the Canadian, and produces, probably, a country not unlike that traversed upon the south. Beyond this the route would cross the new red sandstone and carboniferous formations, developing mines in the coal basin. The most important items of expense on this location, would doubtless be for bridging the Arkansas and Canadian rivers; and, in that respect, the line under consideration from Fort Smith is more advantageous.

† The stations referred to are plotted on the detailed sheets, but the general maps are upon too small a scale to allow them to be represented.

left of station 29. Station 32 is in a wooded ravine tributary to the Canadian. Near by is Camp 34, upon Epsom spring, the water of which is brackish.

From Camp 34 to station 4, several ravines are crossed, with high banks, covered with cotton-wood trees. Station 5 is a quarter of a mile from the Canadian. Station 8, at the foot of the hills, is in the valley of the river. The stream here is shallow, flowing over a wide surface of deep-red sand and clay. The bottom-lands are about half a mile wide, and have the appearance of having been overflowed; containing bushes and weeds, but little grass or timber.

From Camp 34 the line should keep to the left of the trail, edging along the ridge to the valley at station 8. For six miles the broad valley of the Canadian follows a westerly course. The gravelly ridge, which bounds it, is then ascended to avoid a northerly bend produced by the Antelope hills that deflect the river from its direct course. Station 16 is upon the top of the table-land. Station 17 is on a stream covered with cotton-wood timber, and containing good water flowing to the Canadian. On account of its steep banks it is called Cañon creek. Camp 35 is upon the bordering prairie, which extends nearly to the river, a distance of about a mile and a half, where the valley is a quarter of a mile wide. The trail passing between the Antelope hills, to cut off a bend of the river valley, is intersected by several ravines with steep banks. Sandy creek, 150 feet wide, is the largest. Indian creek is near the Antelope hills. Grape creek is remarkable for the number of vines that grow upon its banks. Camp 36 is in the Canadian valley, at the mouth of a dry arroyo. The intermediate country is principally prairie, much elevated at the Antelope hills, and, in some places, sandy. By the trail, the surface of the ground, from Camp 35 to station 3, has a rapid ascending grade, being 284 feet in two and three quarter miles, or 103 feet to the mile. From station 3 to station 9 the grades are easy. From 9 to 10, one mile, the difference of elevation is 135 feet, in consequence of station 10 having been taken in a ravine which might be avoided by an embankment or bridge. Thence to station 16, the grade is light. From 16 to 17, a quarter of a mile, the difference of elevation is 63 feet. This could be avoided by keeping to the left of the ridge between stations 16 and 21. From station 17 to the Canadian the distance is one and a half miles; from station 21, one mile; and between Camps 35 and 36, the greatest estimated width of the table-land, which slopes down towards the river, is two and a half miles. The distance by the valley will not much exceed that by the trail, and the former would be adopted as the line of location, so as to avoid the heavy work and steep grades above referred to.

From Camp 36, to avoid the soft alluvial soil of the valley, the wagon-road ascends about 150 feet, to the gravelly prairie that bounds the Canadian river. The plain is considerably cut up by water-courses, many of them dry. The highest part crossed is about a mile beyond station 1; and from that point there is a slope to a ravine, 200 yards wide, containing good water. Opposite station 2, upon the left bank of the Canadian, there is a ridge of sand-hills, with trees at the foot. A rivulet of clear water crosses the trail near station 7. At station 9 there is a dry arroyo, with banks covered with cotton-wood. Beyond station 10 the valley of the Canadian is well wooded. The trail, after passing several sandy beds of streams, crosses a creek with running water, between stations 27 and 28. Camp 37 is on a rivulet emptying into the Canadian. It contains good water, with cotton-wood upon its banks. From Camp 36 to this place the trail is about a mile south of the Canadian river. For a railroad, the valley would be followed at small expense, and with a uniform grade.

Leaving Camp 37, the trail enters the Canadian valley near station 1, where the alluvium upon the right bank of the river is about one mile in width. It is covered with timber. Upon the opposite side the width is half a mile. Beyond, the valley increases in width. Groves of cotton-wood occur, sometimes upon the right bank of the river, sometimes upon the left. Mounds 15 feet in height, and numerous ravines, appear in the vicinity of station 8. Between stations 10 and 11 is Dry river, with a gravelly bed 200 yards wide one mile from its junction with the

Canadian. Beyond are sand-hills, thinly covered with grass. At station 12 the sand ends, and clay appears. From station 13 to station 20 the trail keeps the edge of the valley, from half a mile to a mile distant from the river. Upon the opposite bank are cotton-wood groves. Passing two dry arroyos with wide sandy beds we reach Camp 38, which is within the wide delta formed by the junction of Wine creek with the Canadian valley. Grape-vines grow in profusion at this place, covering many acres, and loaded with fruit.

Along the river, a short distance beyond Camp 38, are Chickasaw plum, hackberry, and willow trees. Opposite station 2 no timber exists upon either side of the river. Beyond station 3 there is a sparse growth of cotton-wood. From station 8 to station 9 are found ash, cotton-wood, and hackberry. Beyond station 11 the valley opens to the width of two and one-eighth miles. Small, isolated hills appear near station 12, with cotton-wood and willows in the valley. These hills seem to bear some relation to a long range of natural mounds which extend towards the south. There are sand-hills in the valley opposite station 19, and at station 20 is a cotton-wood grove, near the mouth of a rivulet. Between stations 21 and 22 is Valley river, a fine stream of water, with fertile banks about three-quarters of a mile wide. Camp 39 is situated near its junction with the Canadian, overlooking a pleasantly diversified region of wood-land and meadow.

Above Camp 39 a range of small sand-hills intersects the south side of the valley. For the purpose of avoiding it the trail crossed the stream at the mouth of Valley river. The Canadian is there one-third of a mile wide, and three feet deep in the largest channels, which are separated by sand-bars. The northern bank is sandy, and the valley wide. At station 15 the stream was recrossed. Here the bed of red clay and sand measured 840 yards in width. The flowing stream was 150 yards wide, and from one to two and a half feet deep. Station 16 is on the southern bank of the river, and from Camp 39 to this point there is no visible obstruction to the formation of a road upon either side of the valley. The naked sand-hills referred to are small, and do not appear to be continuous to the river. To avoid a miry slue, a ridge of similar sand-hills was crossed beyond station 17. Thence to Camp 40 the valley continues wide and somewhat sandy, with few trees upon the banks of the stream.

About half a mile beyond Camp 40 is a rivulet called Spring creek, three feet wide, its banks lined with cotton-wood trees. The valley of the Canadian continues to average from a mile to a mile and a half in width, thinly covered with trees. Between stations 3 and 4 there is a valley, bordered with cotton-wood trees. Near station 5 the prairie that bounds the Canadian terminates in a bluff edge 150 feet high. Some detached fragments of it form isolated hills of sand and gravel. At the foot of the hill, near station 6, there is a spring. Another is found in the Canadian valley between stations 6 and 7. A stream of clear water called Bluff creek flows past station 11 to the Canadian. Its bed is 30 yards wide, and the banks sandy. Beyond, the width of the valley averages about half a mile upon either side of the Canadian. Near station 26 the bluffs of the right bank approach to within 800 or 900 feet of the river, while upon the opposite side the valley spreads out to the width of two miles. Between stations 27 and 30 the valley is bounded upon the south by a nearly perpendicular limestone bluff. Beyond, the slopes of the prairie become gentle. From station 30 to 32, upon the south side of the valley, there are gravelly knolls. From station 32 to 34 a spur of hills comes down to the river. It is of soft sandstone and gravel. The trail crosses by threading two ravines, which head near the summit. The width of the ridge is 400 yards, and the height of it 56 feet. This is the only point yet seen in the Canadian valley where deep cutting may be required. Camp 41 is in the bottom-land near the western side of the spur. The fall of the river from this place to Camp 34 is seven feet per mile.

Beyond Camp 41 the wide river valley is bounded by a bluff composed of rock, sand, and gravel. Opposite station 2 there is a ravine between the hills. It is clothed with trees and a rank growth of weeds, but shows no worn channel for the water which it drains from the prairie during wet weather. On the north side of the river the prairie slopes gradually down

to the valley, until opposite station 1. There it is edged by a perpendicular bluff, composed of red marl, limestone, and sandstone, approaching within 150 yards of the river. On the right bank the alluvial bottom-land continues a quarter of a mile wide. Between stations 5 and 6 flows Mole creek, a rivulet six feet wide and one foot deep. At the foot of the bluff near station 8, is found red sand strongly impregnated with common salt. There are pools of salt water in the vicinity. At station 10, to avoid a cañon at the Agate bluffs, the trail leaves the valley of the Canadian, enters a wide ravine with irregular banks, ascends near to its head, and at station 11 rises to the high, rolling prairie, which slopes gently from the Llano Estacado. Station 14 is upon the high table-land, which is covered with short grass. The soil is a mixture of sand, clay, and a little gravel. Between stations 19 and 20 is a water-course with gently sloping banks. Another is crossed between stations 25 and 26, near Camp 42. It is sixty yards wide, containing pools of water and bound by rugged banks.

Should it prove necessary for the railroad to emerge from the Canadian valley at station 10, and ascend, by the sides of the ravine, to the high prairie which the trail passed over, for the first five miles a grade varying from 92 to 70 feet per mile would be required. The general slope of the plain is about 18 feet per mile; but it is considerably cut up by ravines, some of them having steep banks which would render heavy cutting and filling necessary in order to produce moderate grades. According to the profile the maximum grade would be 60 feet per mile.

From Camp 42 the trail continues upon the same undulating prairie at a distance varying from three to six miles from the Canadian, which there flows in the cañon formed by the Agate Bluffs described by Lieutenant Abert. Having traversed the table-land for a distance of about 25 miles, we descend with a grade of 60 feet per mile to the border of a beautiful stream called Shady creek. The broad valley through which it flows to the Canadian is covered with a forest of timber, consisting of cotton-wood, white oak, and hickory. To the left of the camp there is a small hill composed of dolomite, and beyond is a bluff of red sandstone. The grade between Camps 42 and 43 would not exceed 60 feet per mile. At station 17 there is a bed of an arroyo 100 yards wide, with steep banks, across which a bridge or embankment would be necessary. Shady creek would require a bridge, materials for which, both of wood and stone, can be found in the vicinity. The proposed railroad line follows this stream to its mouth, and thence ascends the valley of the Canadian to the junction of Tucumcari creek. For a description of the portions of the Canadian river not fully explored by us, reference is made to the published reports of Major Long and Lieutenants Abert and Peck.

From Shady creek our own trail passed over a portion of the Llano Estacado, and crossed Tucumcari creek about 30 miles above its junction with the Canadian. The following notes relate to this line:

From Camp 43 to station 1, which is 75 yards distant from Shady creek, the ascent is steep. Station 2 is one mile south of the stream. There is but little timber opposite this place. Between stations 4 and 5 the valley is contracted to one-fourth of a mile in width. At station 5 the steep rocky hill-sides approach to within 60 yards of the trail. Beyond we pass into a ravine, which soon becomes a cañon, 200 yards wide, terminating at a ridge of sand and gravel, which separates it from Red Bank creek. This stream is crossed between stations 11 and 12. It is sparsely fringed with cotton-wood, and contains large pools of water. Crossing other prairie slopes we reach station 16, upon the bank of Amarillo creek, which contains plenty of water, but no wood. Its bed is 30 yards wide. The width of the valley is 400 yards. Beyond, the trail traverses the prairie and crosses two dry ravines. Camp 44 is upon the bank of a stream, where water is abundant.

Station 1, beyond Camp 44, is in a ravine 300 yards wide. Station 2 is near the commencement of a broad mesa. Two arroyos are crossed between stations 7 and 9; the latter having rocky sides covered with small cedar trees. Between stations 9 and 10 is a ravine, deep, broad, and rocky. To the right of station 11 is a rocky bluff. Between 13 and 14 there are large pools of water. The bluffs of the Llano, covered with cedars, are one-third of a mile to the left of

station 16. The country sloping from them is prairie. Station 17 is in a ravine with a few cotton-wood trees. At station 18, the slopes are covered with mezquite bushes. Beneath the Llano bluffs, near Camp 45, there is a pleasant valley abounding in grapes and sprinkled with cotton-wood trees. It is watered by several springs and a small stream called Rincon de la Crux.

The ravine in which Camp 45 is situated extends far back among the hills, breaking the continuity of the precipitous cliffs, and affording facilities for an ascent to the top of the Llano. Upon the edge of it there is a spur of uniform acclivity, which the trail ascends. Station 4 is upon the summit, which, towards the south, appears smooth, level, and of unlimited extent. It is covered with short buffalo-grass, but contains neither shrub nor tree to vary the landscape. Eight miles beyond, the plain is cut by a deep ravine, in which a small stream, called Encampment creek, flows towards the Canadian. It branches, where we crossed it to obtain water, and might have been headed by a slight detour towards the south. Rising to the plain, we continued upon the northerly tongue of the Llano, about eighteen miles, to its western edge, which affords an extensive view. At the foot lies Rocky Dell creek, a rapid brook flowing to the Canadian. From fifty to sixty miles distant, towards the west, are seen the Tucumcari hills. The intermediate country appears like a vast basin, bounded upon the south by escarped bluffs of the Llano Estacado. Near the base of the slopes are dense groves of cedar and piñon, and lines of small cotton-wood mark the courses of many little valleys and streams which traverse this region.

Rocky Dell creek heads in a re-entering angle of the Llano bluffs, near the trail, and affords a way for a descent along its banks to Camp 46. The maximum grade, according to the topographical sketches, need not exceed sixty feet per mile.

Beyond Camp 46, the country is prairie, with gentle slopes, traversed by small rivulets which take their rise in springs beneath the Llano cliffs. Between stations 4 and 5 the trail crosses a ravine containing water, but destitute of trees. The foot of the Llano is two miles distant, and there cedars and piñons are abundant. Emigrant creek is crossed between stations 9 and 10. Station 10 is upon the side of a dry ravine, which is lined with small cotton-wood trees. The remainder of this day's march was upon a plain, a large portion of which possesses a loose friable soil, which, with sufficient water, would doubtless be fertile. It is almost destitute of trees. Camp 47 is near a ravine, which contains large pools of water and excellent grass. Between stations 19 and 20, a grade of fifty-five feet per mile would be required; elsewhere the grades would be easy.

The ground rises gently between Camp 47 and station 2. Between stations 2 and 3 is the crossing of Halt creek, eight feet wide and three deep. It has no trees upon its banks. Opposite stations 4 and 5, the bluffs of the Llano are four miles distant. Further westward, a salient point of it is within a mile and a half of station 12. There, as elsewhere, the foot of it is covered with cedars, excellent for fuel. The whole route to Camp 48 is but slightly undulating, and much of the soil appears favorable for tillage. Several arroyos, containing pools of water, were passed.

Between Camp 48 and station 1 there is a muddy creek. Its banks are destitute of trees. Station 2 is in the valley of Fossil creek, or a branch of it, which contains a sluggish stream of water, bordered by a few cotton-wood trees. Between stations 5 and 6 is a larger rivulet of flowing water, of a clay color; its width is 150 yards. Upon the right of the trail, towards the Canadian, its valley is well supplied with cotton-wood timber. There are trees, also, a mile distant upon the left. Its valley is 300 yards wide. Station 6 is on the bank of this stream, four feet above the water. Station 11 is upon a branch of Tucumcari creek. Near this stream, the trail continues to Camp 49. There is much timber in its valley towards the Canadian. To the left of the trail there are few trees, except at the base of the Llano bluffs. From station 12, the slopes to the river are gentle. The average width of this branch of Tucumcari valley is about half a mile. From station 13 to station 17, the trail is within a few hundred yards of the water; thence to Camp 49, it follows near the valley of Tucumcari creek. In the construc-

tion of a road over this day's march, light grades could be obtained. The main item of expense would be for bridges and culverts, in crossing the streams.

Leaving Camp 49, we ascend a branch of the valley of Tucumcari creek, and find detached portions of the Llano one-fourth of a mile to the north of station 2. The bluffs upon both sides approach the trail near station 4, leaving a valley between about two miles wide. A few hundred yards to the left of the road, between stations 4 and 5, is an isolated hill, nearly conical, called Pyramid mountain. Its horizontal stratification shows it to be a remnant of the Llano. A sketch of it was taken, and a description will be found in the geological report. Between stations 5 and 6, the width of the valley is increased to several miles. At station 6 there is a large pool of water. To the left, the hills are one and a half miles distant; and the width of the valley beyond, to Camp 50, on Laguna Colorada, varies from one to three and a half miles. Between stations 14 and 15, the ground is marshy and covered with bushes; below, there is a stream. A rugged hill, of the red sandstone formation, bounds Laguna Colorada upon the north.

Camp 50 lies in the basin of Laguna Colorada, near large pools of shallow water. Between stations 2 and 3 there is a thick grove of cedars; and the valley opens to four and a half miles in width. Near station 7, the trail crosses a rocky hill, which is sprinkled with pine trees. Station 10 is in a valley one-fourth of a mile wide—a branch of Pajarito creek. Opposite station 13, the hill-slopes contain timber of cedar and pine. There is a large pool of water at station 14. The range of bluffs continue upon the left of the trail, but recede from the right, making room for the tributaries of Pajarito creek. Between stations 17 and 18 is a ravine, containing pools of water. At station 18, the total width of valley is five miles. The slopes are gentle; the bottoms are covered with luxuriant grass. Camp 51 is upon one of the numerous branches of this creek. Water is plenty in springs and pools, but is slightly brackish. Large cedar trees are abundant upon the hills, about a mile distant.

From the notes of the survey, it is evident that, from Fort Smith to this place, little difficulty would be experienced in constructing a railroad in the immediate vicinity of our trail. The reconnoissances, however, covered a larger extent of country; and, taken in connexion with the reports of others, have led to some deviations from that line. The section delineated by the profile avoids the cañon of the Agate bluffs, by passing the table-land south; re-enters the Canadian valley at the mouth of Shady creek; ascends its banks to the Spanish road, near the mouth of Tucumcari creek; and thence threads the wide valleys that receive the waters of Laguna Colorada, Cuerbito, and Pajarito creeks. This route enables us to avoid the ascent to the Llano Estacado at Rincon de la Cruz, and to maintain more nearly the uniform grade of the valley. The trace marked out, near Lieutenant Abert's trail, crosses to the north side of the Canadian valley; it is quite probable, however, that the right bank of the river would afford an equally good location for a road, and thus enable us to avoid the construction of expensive bridges.

NOTE.

Extracts from the report of Lieutenant James W. Abert, Corps of Topographical Engineers, commencing August 29th, about fifty-six miles northwest from the junction of Tucumcari creek with the Canadian.

August 29.—We encamped in a beautiful valley which afforded an abundance of grass. In the afternoon Lieutenant Peck and I mounted our horses and started off to make an examination of the cañon. We were caught on a tongue of land which separates the forks of a tributary cañon, and at length found ourselves upon the brink of a stern precipice fron 150 to 200 feet perpendicular, and on either side was an impassable ravine. These, uniting at our feet, swept onwards to join the river. Through the bottom a small stream of water pursued its meandering

course, silent and slothful. The rocks on both sides were cut down vertically, so as to render it impossible to clamber down even a foot. * * The rocks were highly ferruginous sandstone, rusty and blackened by oxidation, and harmonized well with the dark green foliage of the cedar. Latitude 35° 50″ 43′; longitude 104° 10′ 19″.

August 30.—In our journey to-day we have been forced to bear strongly towards the east, in order to avoid the deep gullies which, in rainy weather, serve to drain the elevated plain upon which we now found ourselves; for, on looking to the south, we saw it suddenly break off, and the eye plunged into an ocean of mist floating over a prairie of indefinite extent far below, now and then pierced by the tops of seeming islands whose summits, on a level with our feet, had once formed an integral portion of this plain. Here the river escapes from the jaws of the cañon, where the rocks are piled up to the height of 600 feet. Being everywhere covered with a dense growth of timber, they present very much the appearance of rising mountains. * * * The valley of the Canadian, four or five hundred feet below, lay spread out to the breadth of twelve or fifteen miles, roughened by isolated ledges of rock and curiously shaped buttes, being bounded on the opposite side by cliffs scarcely discernible. * * * Continuing our journey, and constantly forced by the nature of the country still further from the river, we reached a passable camping ground in the bottom of a small ravine, * * having made a march of twenty-two miles. We found here plenty of grapes and plums, the latter not yet fully ripe. This country abounds with timber, and on an elevated ground to the east of us is a fine grove of timber. * *

August 31. (Valley of Utah creek.)—As we found ourselves getting still further from the route we wished to pursue, * * we resolved to attempt the descent. * * Having cleared the loose fragments of rock from an inclined slope of 150 feet in length, which terminated in a shelf, and from which we thought to find a winding path to the bottom, * * the wagons, by means of ropes, were let down. * * * The stream we first struck was the Arroyo de los Yutas, or * * Salt creek. That which we finally encamped on was a tributary to it. The Sandy plain over which we had just passed was strewn with numerous flowers, which indicated a change of soil. * * Latitude 35° 41′ 56″.6; longitude 103° 45′ 5″.

September 1. (Utah creek.)—Before we had proceeded far we found a rapid running stream. * * * The valley, though sandy, appeared fertile. * * A grove of large cotton-wood, surrounded by a natural meadow of fine tall grass, made our camp one of the best we had found. * * To the south the beautiful valley of the Canadian spread out, covered with scattering "buttes." * * A heavy line of timber marked the course of the river itself, and we judged that we were still twelve miles distant from it. * *

September 2. (Junction of Utah creek with the Canadian, five miles west of the mouth of Tucumcari creek.)—We are now in a shady grove of buttonwood, * * mingled with cotton-wood. Since we left the Canadian, at the "El Vado de Piedras," it has increased to seventy or eighty feet in width, with a deep and very rapid current, so that we could scarcely keep our feet whilst bathing. The bottom in which we encamped is everywhere covered with various species of cactus. * * * Among the sylva, the hackberry * * is quite common, and we observed for the first time an extensive grove of the Pride of India, * * a tree gifted with a beautiful form and dense foliage, not more than thirty feet in height. * * The trees were everywhere loaded with heavy masses of grape-vines, * * which afforded the whole camp a great abundance of fruit. * * * At this place is what is called the "Spanish Crossing," where the people of New Mexico pass with pack-mules on their way to and from the Comanche country. Latitude 35° 20′ 59″; longitude 103° 29′ 38″.

September 3. (About eight miles east of Tucumcari creek.)—We commenced following the Gooalpa, (Canadian,) meeting with scarcely any obstructions, although the road was strewed with the broken axletrees of the Spanish carts that had preceded us. On the way we found quantities of luscious plums. * * * We camped in the Canadian bottom again, near an old Spanish camp. * *

September 4.—The trail led us through four or five miles of high and rounded sand-hills,

wrought into regular form by the winds. * * The day was hot, and as we held our course over the barren waste, without sign of water, we languished, and feared we should not find that necessary article. Our sufferings were greatly alleviated by the refreshing fruit of the plum-tree, which everywhere grew in great abundance; and we found the fruit equal to any of the cultivated varieties that we recollected to have tasted in the United States. * * * We reached a beautiful valley, where we found a clear, cold spring. * * * Our camp was formed under a grove of unusually tall cotton-woods, the characteristic sylva of this region, and which heavily-timbered the course of the rill which flowed from the spring. A few yards north of our camp were a few low "buttes," covered with dwarf plum-trees, profusely laden with fruit. * *

September 5.—We continued on the same trail as yesterday until about 8 o'clock, when, finding that we were rapidly diverging from the river, we were forced to leave it, and to shape our course almost direct for the "Gooalpa." We passed through a sandy country, * * and, after a toilsome march of seventeen miles, reached the bank, cañoned by a bluff escarpment 100 feet high, and absolutely impossible of descent. We were obliged to make a retrograde movement, and camped in a deep, tortuous ravine, where we found a little stream of clear water. * * The valley appeared full of grape-vines. * * We saw to-day an abundance of mezquite, * * thought by some persons to be the same as the "acacia Arabica."

September 6.—After quite a pleasant march on the level prairie we attempted to reach the river, and, knowing that there were high banks which coasted it, we undertook to reach its valley by the way of a tributary ravine. * * * * We find the Canadian still increasing in width and velocity of its waters, which have now a deep tinge, and justly merit the name of Colorado. Latitude 35° 31′ 36″; longitude 102° 47′ 02″.

September 7.— * * * * The sandy bed of the river is here 100 yards wide; the water, dwindled to a small stream by the absorbing material through which it flows, is slowly meandering, and as we travel on is alternately rising and disappearing. After a march of 19 miles we again formed our "kraal" in the bottom. * * * * Our road to-day was everywhere beautified by a luxuriant profusion of plum-trees and grape-vines. * *

September 8.— * * * * About noon we found a stream of cool water which ran swiftly along the bottom of a deep ravine. * * * * We pitched our tents at night on a point lying between the river and the bluff. * *

September 9.—The rain still continuing at intervals, we remained in camp all day. * * * The river had been rising gradually during the day. On hearing a rush of water, and looking out, we saw a foaming torrent, bearing rapidly along with it trunks and branches of trees. * * * * The river immediately doubled in depth and velocity, and, for a moment, threatened to deluge our camp, and at once dissipated our hope of being able to cross it and pursue our journey on the opposite side. We were therefore forced to clear a way along the face of the bluff. * * * The bottom here is pretty wide, and bears marks of fertility, and is walled up by a bluff 100 feet high. * *

September 10.—At an early hour in the morning we were on our way, and soon leaving the bottom, entered a more desolate country than we had hitherto seen. The high and dry table-lands were covered with but a few scattered plants, and were altogether desert-like. The cacti and mezquite were most abundant. * * * Wherever we approached the river we found it swollen and muddy, with a very rapid current. * * * We again found an abundance of prickly pears, grape-vines, and plum-trees. * * * Our day's march was upwards of 27 miles, and the route sandy. * * * We encamped close to the river's banks, which were not more than five feet high, with the bottom extending back 300 feet to the base of the bluffs. Upon going into the river to bathe I found the depth to be two feet. * * * Latitude 35° 27′ 25″; longitude 102° 0′ 6″.

September 11.—At 7 o'clock we found ourselves on our journey, but experienced some trouble by meeting continually with cut rock and deep ravines. Passing into a valley, beautiful in the

freshness of its vegetation, we entered a bottom where the tall grass grew abundantly. As we wound along under a romantic cliff, our progress was suddenly stayed by a projecting bluff which rendered further advance impossible. To cross was impracticable; to recede would occupy too much time; it was therefore resolved to ascend the bluff, which was here very steep and high. * * * Passing onward, the road for a time promised to be smooth, when suddenly an immense ravine yawned before us, and we were on the brink of the river again at a point where it was joined by one of its tributaries. As we looked onward, nothing but red precipices met our view, and they were piled up 250 feet perpendicular, and perfectly impassable. * * * On looking down into the deep cañon, instead of the beautiful green strip at the bottom, which we had hitherto seen, we discovered that it was covered with sand-hills. * * * We now found ourselves obliged to turn back in order to head the ravine we had encountered, * * and encamped on a neck of land between two valleys. * *

September 12.—(No topographical remarks.)

September 13.— * * * Shortly before reaching camp we were obliged to cross the bottom of a creek several times. * *

September 14.—We now travelled down the sandy bottom of the creek for the distance of one-fourth of a mile, several times crossing the broad and shallow sheet of water. Just at the junction with the Canadian we flushed a large covey of quails. Our way now lay along the low lands on the river-side, where the grass grew tall and the sand was deep. * * * The bluffs on each side were filled with gypsum of snowy whiteness, crumbling easily. At one time the river swept down to the base of a projecting spur of the cliff. Our course being momentarily impeded and our embarrassments increasing, we resolved to hazard an attempt to cross the river. * * * The river is about half a mile wide, generally shallow, though in some places belly-deep to the mules. * * * A short distance below our ford we found a pretty good camping ground. * * * Latitude 35° 47′ 56″; longitude 101° 35′ 47″.

September 15.— * * * Continuing on down the Canadian, we found the country around us composed of gypsum. * * * The bottom lands were very well timbered with cotton-wood, which in some places formed extensive groves. * * * Plum-trees are in abundance, and grape-vines in wild luxuriance, completely enshrouding the shrubbery which upheld them.

Lieutenant Abert says that on the 27th of September, in longitude 99° 11′, on the north side of the Canadian, he passed through a country "completely covered with a dense growth of oak, commonly called blackjack oak," the trees not more than 30 feet in height. These forests stretched back from the river as far as the eye could reach, forming a portion of the celebrated Cross Timbers. In some of the bottoms, "where the trees were of a more luxuriant growth," he found "the bur-oak."

SECTION III.

From the head of Pajarito Creek to the crossing of Rio Pecos, forty-four miles.

Thus far the line of location has threaded the principal valleys; leaving them, only from choice, whenever a decided advantage could be gained by it. In this section, upon the other hand, it will be necessary to cross a dividing ridge, and intersect several chasmed streams nearly at right angles to their course.

It is probable that the valley of Tucumcari creek extends far towards the southwest into the Llano, and forms a favorable passage to a branch of Rio Pecos; connecting our route up the Canadian with the line explored by Colonel D. S. Miles, and referred to in his letter to Colonel Abert, which is appended to the preceding *itinerary*. If so, this would unite the Canadian with Rio Gila; and make available, for one route, the two great valleys that, extending east and west, cover so large a portion of the distance between the Mississippi river and the Pacific ocean.

Pajarito creek has its source in a chain of hills that connect the flat-topped Llano on the south with lofty fragments of the same that exist towards the north, and form the great cañon of the Canadian. The ridge is considerably broken. Its slopes are broad, and, by winding around them, little difficulty would be experienced in obtaining moderate grades. From the top of this prairie to the banks of the Pecos the country continues high and undulating, with few spots fit for cultivation. Hurrah creek and two branches of Rio Gallinas cut through it, making it necessary to adopt heavier grades than were generally required upon the previous section; the maximum being 78.3 feet per mile. Upon this section there is plenty of fuel, but timber is wanting. For oak we must have recourse to the Cross Timbers. Forests of pine are found nearer at hand, upon the highlands bordering the Pecos. The streams crossed may be easily bridged; the materials for masonry being abundant upon the banks. Below Anton Chico there is a long, sloping bank leading gently down into the Pecos valley. The ascent to the high plains upon the western bank is rough and difficult. However, with a grade of 93.7 feet per mile, it is not impracticable; and the profile is constructed upon that route.

From the springs at Las Chupainas a westerly course would conduct to the crest of the bank overlooking the Pecos, and thence along the side of a spur which abuts upon the river a short distance above Anton Chico. On the opposite bank approaches a bluff of the cañon having nearly the same height. A viaduct thrown over the river there would save a descent of several hundred feet. Sandstone, limestone, and gypsum could be obtained in the vicinity for such a construction. Forests of Douglass' spruce are abundant upon the neighboring heights, affording good material for railroad ties. Upon the mountains, from twenty to thirty miles distant, there is a supply of pitch-pine timber of large size, well suited for the purpose of bridge-building. La Cuesta is fifteen miles west-northwest from Anton Chico; and the difference of level between the two places, as indicated by barometer, is five hundred feet. This would show a fall in the river of about 30 feet to the mile. The bluffs between which the Pecos flows, as observed at La Cuesta, are five hundred feet in height. Below, they are said to form a very narrow cañon; and it might be found advantageous to follow the left bank to this gorge, where, probably, a shorter viaduct would serve to unite them, and place the road on the general level of the country. The following notes from the field-books are more specific regarding the details of the topography on the trail.

Between camp 51 and station 2 there is a water-course. To the right of station 2 the bluff edge of the high mesa is five miles distant. It is rocky, and, as elsewhere, covered with fir trees. At station 4 the bluffs upon the left are but sixty yards distant. From stations 4 to 6 the prairie extends two miles to the right of the trail; and after passing the summit which separates the waters of the Canadian from those of Rio Pecos, it slopes gently towards the left two and a half miles. There is a large pool of water between stations 13 and 14. The prairie extends three miles upon the left and two and a half miles on the right of the trail. Camp 52 is upon the bank of Hurrah creek, four miles above its junction with the Gallinas. It is a clear and rapid stream, destitute of wood.

From Camp 52, on Hurrah creek, to Camp 53, at Las Chupainas, is a high broken prairie, intersected by many ravines. Near station 3 is a ravine the bed of which is 20 feet wide. From station 3 to 4 the ascent is steep; beyond there is a wide plain. Between stations 8 and 9 is a stream, with pools of water. Station 15 is in the water of Rio Gallinas, which contains neither wood nor soil fit for cultivation. There is a stream of water between stations 18 and 19, and another at Camp 53, the water of which proceeds from the springs of Las Chupainas, and is slightly brackish. There is fuel, but no good timber, upon the slopes of the mesas back of camp. Large forests exist some miles distant towards the Santa Fé mountains.

North of Camp 53 is Man-of-War mountain, a high, mesa-capped peak in a range of new-red sandstone hills that extends towards the northwest and bounds the Pecos valley. The sides are steep, rocky, and covered with cedars. A secondary spur, of nearly the same altitude as the general surface of the high prairies, extends from this place to the Pecos river above Anton Chico. From Camp 53 to station 1 the trail crosses the wide and fertile basin which is watered by springs from the bluffs. There are pools of water near station 2. Thence to station 8, in the Pecos valley, the descent is by a long and regular slope. The river is crossed between stations 8 and 9, its stream being about fifty feet wide and two and a half feet deep and the bed rocky. Station 9 is at Camp 54, upon the west side of the Pecos valley, a few hundred yards from the river. The village of Anton Chico is about three-fourths of a mile above, overlooking the river and a wide extent of cultivated valley.

SECTION IV.

From Rio Pecos to Rio del Norte, one hundred and four miles.

Having reached the top of the bluffs which bound the western edge of the Pecos valley, our route, as far as the entrance to Cañon Blanco, lies upon an elevated table-land, the geological strata of which, by the upheaval of the Rocky mountains, have been tilted from 15° to 20° to the east. The surface is somewhat broken by wooded hills and broad valleys leading to the Pecos. The descent is easy into Cañon Blanco, which for several miles forms an excellent location for a railway. To issue from it, near the head of one of its branches, and cross a low ridge which separates its waters from those of Laguna, would require considerable labor. The summit may be reached by edging along the side of the cañon and throwing a high embankment across a branch ravine. The profile, however, follows to the head of one of the branches, and makes a deep cut through the crest of the ridge. This summit, the most elevated crossed by our trail between the Mississippi river and the Rio del Norte, is 6,943 feet above the level of the sea; and, although its elevation above the prairies, east and west, is but slight, it may be considered as the Pass of the Rocky mountain chain.

Laguna, which lies a short distance west of the ridge above referred to, is a depression in the prairie, which receives the drainage of a wide surface, and forms a natural reservoir, containing a large supply of water. From this point, looking west, are seen the Zandia mountains, about thirty miles distant. To the north lie the mountains of Santa Fé. Between these two masses of mountains there is an opening, through which Rio Galisteo flows to Rio del Norte. South of Zandia mountain is seen a depression in the chain separating the Zandia from Manzana mountain, and forming the Pass of San Antonio, which leads directly to Albuquerque, or to Isleta. Eastward of that range, and from the vicinity of Santa Fé on the north, to the Salinas on the south, lies a prairie, the general surface of which is somewhat undulating, and occasionally traversed by ravines. The crest, which bounds it upon the east, seems to possess about the same height at the head of Rio Galisteo as at the point already noticed near the Laguna. This appearance, connected with subsequent observations, led to the belief that a railway might ascend the east bank of the Pecos to some favorable crossing place, said to exist in the vicinity of San Miguel, and thence pass into the valley of Rio Galisteo, which leads to the Del Norte, near San Felipe. Our own explorations for a crossing of Rio Pecos were confined to the vicinity of Anton Chico and La Cuesta. This river, as has been stated, flows in a deep cañon, with a ribbon-like valley of excellent soil enclosed within bluff banks near the villages mentioned. Between those places the cañon is contracted to a narrow chasm, which may be surmounted by a viaduct. Its construction might involve greater expense than would be required by the route upon which the profile is traced; but it would cause a saving both in distance and in grade.

From Camp 54, near Anton Chico, to station 7, the ascent by the road is steep. There is a ravine further south, through which the profile is carried to obtain a practicable grade. Station 8 is at the summit of the acclivity; and beyond, the general surface is moderately undulating. In the vicinity of station 10 are hills covered with forests of pines and cedars. Near station 11 is a peak 200 feet high, and higher hills appear two miles distant upon the left. From station 11 to station 13, the surface is a prairie. From 13 to 15 are cedar trees, and at station 17 are

hills covered with the same. The slopes are gentle to station 23, where the width of the valley traversed is contracted to 100 yards. From station 25 to station 28, the trail passes through a thick forest of large pine trees. Upon each side of the road, from station 21, and a quarter of a mile distant, are high hills, steep and rocky; those upon the right are covered with cedars. Here, by a gentle descent, we enter Cañon Blanco, a wide chasm, whose rocky sides are covered with pines and cedars; and beside a pool of water is Camp 55.

Cañon Blanco extends from Camp 55 to station 16. Its width is variable, being at station 1 five hundred and forty yards; at station 3 one and a half miles; at station 4 one mile; and at station 6 half a mile. At the narrowest point, between stations 6 and 7, the width is one hundred and fifty yards. The sides of the cañon are rocky, steep, and covered with small cedar trees. It has many branches; the main one drains the waters from station 3 towards the southeast. At station 16 the trail issues from the cañon and, passing a crest to an undulating prairie, reaches Camp 56, near large ponds of water called Lagunas.

From the Lagunas, two routes, as before mentioned, lead to Rio Grande; one by way of San Antonio Pass, between Zandia and Manzana mountains, to Isleta, twelve miles south of Albuquerque; the other, more northerly, along a branch of Rio Galisteo, around the Gold mountains, to San Felipe. Both routes were found practicable, and each intersects the Del Norte at a point favorable for bridging. The slope by Galisteo commences directly, and is nearly uniform through its whole course. The grade would scarcely exceed thirty-five or forty feet per mile; while, by San Antonio, a maximum of 105.7 feet per mile would be required. There is much tillable land in the Galisteo valley, but no timber; that could be obtained among the Zandia mountains, from ten to twenty miles distant.

The more direct route from the Lagunas to the Rio del Norte, via the San Antonio Pass to Albuquerque or Isleta, was explored by A. H. Campbell, Esq., my principal assistant engineer. The following description of this part of the line is taken from his report, and the accompanying cut, representing the Pass of San Antonio, has been taken from his sketches:

"*From the Pecos to Albuquerque via Rio San Antonio, or Cañon Carnuel.*—The problem of leaving the Pecos is a more difficult one than we have yet had to solve. There are, however, two methods which are practicable in the vicinity of our exploration, and I doubt not that by following the river to one of its valleys heading with the Galisteo, a very easy mode of crossing the Rocky mountain range can be accomplished. To determine a suitable point for crossing near Anton Chico, and to even approximate to its cost, would require very careful surveys with the level and the compass. The approach from the east is not so difficult. The river can be crossed with a single span of 150 feet at Anton Chico, or about half a mile below with a less span.

"Proceeding, then, from either of those points, one route would lead up a small valley south of the town, which heads in the elevated plateaux through which the Pecos cañons, as at Cuesta; pusuing a westerly course thence, over a rolling region, to Cañon Blanco. The average ascent per mile to this point is but forty-three feet, but the maximum grade for the first ten miles will be at least eighty feet per mile. The other route from the Pecos would cross the river some four or five miles above the town by a viaduct, at an elevation of from 150 to 200 feet; thence to a point some ten or twelve miles from Anton Chico, connecting with the other route to the summit between Cañon Blanco and the Pecos. This route would be several miles the shorter, and the maximum grade probably not exceed seventy feet per mile. The great cost of a viaduct on this route, however, would render it a question as to which of these routes would be preferable. From the entrance to Cañon Blanco, the line explored pursues that cañon to near its western limit; thence, over the divide, into the basin between the Rocky mountains and the Pecos. For several miles the ground descends in the cañon to about half-way through; thence ascends to the divide above mentioned. The drainage of this cañon is southeasterly, probably to the Pecos, the main cleft opening and descending in that direction. The grades through Cañon Blanco will be light, not exceeding twenty feet per mile, except at the western

limits, where it will require at least sixty feet grade, and from thirty-five to forty feet cutting, to attain the summit. From this summit, a little south of Las Lagunas, to the main summit of the Rocky mountains, at the San Pedro mountain, the line traverses a rolling country, descending at an average rate per mile of about thirty-three feet to the lowest point of this basin, which drains, it is supposed, into or towards Las Salinas. From this point the San Pedro Pass can be approached with a grade of about thirty-five feet per mile.

San Antonio Pass.

"This pass divides the waters which flow into the Rio Tuerto from those that flow into, or towards, Las Salinas. About nine miles farther is another pass or summit, which divides the waters of the Tuerto from those of the Rio San Antonio, in the Cañon de Carnuel, with a forty-feet cut at the San Pedro summit, and a descending grade of about eight feet per mile for seven miles. We pass the second summit with only about forty feet cutting, and thence descend at the rate of about eighty-two feet per mile for thirteen miles; thence down the sloping mesa to the Rio Grande, opposite Isleta, at a rate of about from twelve to fifteen feet per mile. At Isleta the Rio Grande contracts through a comparatively narrow gorge, presenting a most favorable point for crossing. Three spans of from one hundred and fifty to two hundred feet will effect this object, there being a bluff on both sides favorable for landing without embankments."

SECTION V.

From Rio del Norte to Flax River, 237.5 miles.*

Bridging the river at San Felipe or at Isleta would not be a difficult operation. Few of the principal railroads in the eastern States are without structures of equal magnitude. From the point selected, a gentle curve toward the south would enable the engineer to ascend the steep slope of the high table-land which divides the Del Norte from Rio Puerco. Thence, passing to the latter stream, he would reach its junction with the valley of Rio San José, which extends westwardly to Campbell's Pass of the Sierra Madre. To this point the grades would be light, the maximum being 53 feet per mile. Excellent spruce and pine timber is plentiful upon the slopes of Sierra Madre, and may be easily obtained. Material for masonry is also sufficiently abundant.

By the term "Sierra Madre" is meant—according to Mr. Gallatin†—"that ridge which separates the waters that fall into the Atlantic from the rivers which empty into the Pacific ocean, without any regard to its elevation." Near the sources of Rio Gila it is a lofty range. Below the parallel of 32° 30′ the chain is broken, and divided into a series of minor ridges, having crests, more or less prominent, extending in the same general north and south direction. Near latitude 32° this system is extended to about 3° in width, and the low swelling ridges form a succession of basins, without any surface outlet for their scanty supply of waters. Here rains are absorbed by the sandy soil, or are evaporated from the mineralized surface of some shallow lake. The most favorable passage of the Sierra Madre range that can be found north of the head-waters of Rio Gila, is probably at Campbell's Pass. This, although more elevated than those of the Mesilla country, possesses but one crest intervening between the waters of the Atlantic from those of the Pacific. It is a wide gap, separating the ridge known as the Zuñi mountain from the Sierra de San Juan; upon the east the waters of Agua Azul flow through the open valley of San José, and a rill from the spring of Ojo del Oso courses along the gentle declivity which forms the Rio Puerco of the west. The great advantages of this pass of the Sierra Madre consist in its single summit; in the easy grades by which it may be approached east and west; in the convenient positions of springs and streams; and in its close proximity to forests of good timber.

Westward from this point we have the valley of Rio Puerco of the west, extending in a general west-southwest course for 121 miles, to its junction with Flax river; the average grade being about thirteen feet per mile. After leaving the slopes of the Sierre Madre the sylva consist of cedars upon the prairies and a few cotton-woods upon the banks of the streams; the pine forests of the Zuñi mountains contain an ample supply of timber for this section.

The main survey crossed the Sierra Madre by the pass of the Camino del Obispo, and thence traversed the valley of Zuñi. The following notes relate more particularly to that line.

The valley of Rio Grande from Albuquerque to Isleta, fourteen miles, is wide and fertile. It contains several villages and large *haciendas*, surrounded with well-cultivated fields, which are irrigated by numerous *acequias* that traverse the bottom-lands. Upon the west it is bounded

* Flax river is the translation of "Rio del Lino," the first Spanish name given to the stream lately known as the Colorado Chiquito. As there are already within our territory many rivers named Colorado, it would seem desirable to withdraw this from the list.

† See letter of Hon. Albert Gallatin, in Major Emory's report, Ex. Doc. No. 41, 30th Congress, 1st session.

by the bluff edge of the mesa, 700 feet in height, that divides it from the valley of Rio Puerco. The best point for ascending it is below Isleta. Between Albuquerque and Atrisco the river is wide, shallow, and usually fordable—measuring 650 yards in width, from bank to bank, and two to three feet in depth, in two channels which enclose a shifting sand-bar. The banks are flooded during freshets. The crossing at Isleta is much more favorable for the construction of a bridge. Spurs, from twenty to twenty-five feet in height, from each side come down to the water's edge, and the width of the river between is about 800 feet. The bluff of the Puerco mesa here makes a salient point, but below forms a re-entering angle back of Las Lunas, where a wide and open ravine leads by a gentle ascent near to the top. The valley of Rio Grande, opposite the village, is wide, and upon both sides of the river are groves of timber.

The ascent from Isleta commences at station 1, and follows the edge of the mesa slope. Considerable lava and volcanic cones were found in the vicinity of the trail. The soil of the lower portion of the hill is sandy. The upper stratum of the mesa is a rocky cliff, nearly unbroken upon our right until we reach the water-course at F. Station 4 is upon the top of the mesa. Thence for several miles the surface is nearly level, and beyond, we gradually descend by a wide ravine to the Puerco valley, near the mouth of Rio San José.

From Isleta, with light cutting and filling across the gentle spurs, and by keeping higher upon the slope to the right of the trail, the maximum grade to station 3 would be 52.5 feet per mile. From station 3 to station 4, with a maximum filling of 30 feet, the grade is 76 feet. From 4 to 5, the location is on the top of the mesa nearly level. From station 5 to Camp 62, the grade is from 46 to 56 feet per mile.

At Camp 62, the bed of Rio Puerco is 18 feet below the alluvial soil of the valley. It can be bridged with a span of 100 feet. The tongue of land included between Rio San José and the Puerco is formed by a ridge of hills, with flat tops, covered with cedar trees. The trail crossed this ridge a few miles north of the valley of San José.

The ascent to the hills is quite steep. From station 1 to station A, the soil is composed of clay and sand. Twenty-five yards to the left of station A is a hill containing coal. Station 2 is between two hills, 20 yards distant and 20 feet in height, composed of sandstone. At station 3 commences an ascent of 200 feet in two-thirds of a mile, station 8 being upon the summit. Station 12 is in an arroyo 50 feet below the general surface. To the left of station 16, one mile from the trail, are hills covered with cedar trees. From station 15 to 16, the ground has a general slope towards the San José valley upon the left. To the right of the trail there is a range of hills with rocky sides. At station 16 they come within 20 yards of the trail, and are 85 feet high; somewhat further on, they are composed of red and white sandstone. The valley extends to the left about a mile, and is bounded by a mountainous range covered with cedar-trees. About station 17 the soil is sandy, with but little grass. One mile to the right of the trail, from station 17 to 19, there is a range of hills 120 feet high. The base is formed of a stratum of red sandstone. Thence we follow the wide valley of Rio San José, in which is the deserted valley of Rito, to Camp 63, where steep, rocky banks approach the river, forming a cañon. On the right, the red sandstone bluff is 300 feet high. The stream here, usually called Rio Rito, is a good-sized brook; the water is slightly impregnated with salts.

The route from Rio Puerco to Camp 63 should follow the valley of Rio San José, which affords a light grade, 17.5 feet per mile being the natural inclination of the stream. The trail is less favorable; though in the vicinity of it, with considerable cutting and filling, a line may be traced whose maximum grade would be 70 feet per mile for a distance of two and a quarter miles.

Between Camp 63 and the Pueblo of Laguna, the San José river is deflected towards the north by a spur of hills, at the point of which a narrow cañon is formed. The wagon trail is across the hills; though with some labor in rock cutting, the banks of the stream would doubtless afford a better location for a railroad. From Camp 63, the trail follows the edge of the stream to station 4, where it turns into a ravine upon the left, and ascends the high lands. From station 7 to 10, the rise is 79 feet in a third of a mile. Thence, passing the crest, the descent is

moderately gradual to station 11, in the valley of La Laguna. From station 11 to 12, the trail crosses the river. Above this point there is no obstruction in the wide valley of San José. The road, however, passes over the rocky eminence, about 70 feet in height, upon which stands the Pueblo of Laguna. Thence it follows near the edge of the bluffs, which upon the north bound the cultivated basin of La Laguna, to a branch of the valley leading to Covero.

The direct route from La Laguna to Camp 65 is through the valley of Rio San José, leaving Covero about two miles to the north. That by the trail, however, may be followed with nearly equal facility. It leads from Camp 64, through the town of Covero, to a broad plain which slopes gently from San Mateo to Rio San José. Station 7 is upon the edge of that stream, where the banks are steep, and the channel 20 feet in width. There are cedars upon the hill-slopes, but no timber in the valley. Thence the trail to Camp 65 follows the narrow belt of alluvial soil that borders the river; the bluff banks enclosing it increasing from 50 to 150 feet in height. About two miles north from station 10, is the foot of a bluff which bounds the mesa surrounding the volcanic peak of San Mateo. It is about 1,000 feet in height; and, at station 15, approaches to within 300 yards of the river. At station 17 the valley is one mile in width, and thence to Camp 65 it is covered with luxuriant grass. The hills upon both sides are covered with cedar and pine timber. The river flows beside, and sometimes beneath, a broken *coulé* of lava which threads the valley. The grades are easy from La Laguna to this point.

Near Camp 65 the trail crosses the river and ascends the valley with nearly a uniform grade, via Ojo del Gallo, Agua Azul, and other head springs of Rio San José, to the wide opening at Campbell's Pass, 6,952 feet above the level of the sea. Upon the left are the Zuñi mountains, covered with forests containing several varieties of excellent pine timber. From the summit westward for about three miles, to Ojo del Oso, the head springs of Rio Puerco of the west, the surface is somewhat broken, requiring a moderate amount of cutting to attain a uniform grade of 50 feet per mile. Thence the Rio Puerco of the west leads through a wide valley toward the west-southwest, crossing the trail from Fort Defiance about twenty-five miles north-northwest of Zuñi, and coursing onward to Flax river, with which it unites near the mouth of Lithodendron creek.

The wagon route through the Obispo Pass and along the Zuñi river struck the Puerco of the west near the Navajo springs, at Camp 74. The region traversed is fertile, but unfavorable for a railroad, on account of the high altitude at which the Sierra Madre was crossed, and the necessity of a tunnel at that place. The grades through Campbell's Pass and along Rio Puerco of the west are highly favorable; but the river, though at all times containing large pools of water, is not a constantly flowing stream, and its banks are destitute of timber. Cedar forests, however, cover the mesas in the vicinity. Near its mouth, the Puerco, like Lithodendron and other creeks in that region, cuts through the gravelly mesa, and forms deep ravines which would require bridging. Quarries of sandstone, fit for masonry, may be found in the vicinity of the valley of Flax river.

SECTION VI.

From Flax River to Rio Colorado, 307.7 miles.

It is much to be regretted that a greater length of time could not have been devoted to the examination of the region embraced in this section. It is full of interest, and probably no other portion of our territory would so richly recompense the cost and labor of a minute exploration. The region referred to is mainly included between the Gila and Colorada rivers, and their principal tributaries, Rio Verde and Flax river. The latter, having its sources in the Mogoyon and Zuñi regions, flows west and northwest to the Colorado, with which it is supposed to unite near the head of the celebrated Great Cañon. Thence, the Colorado is said to course westward, through a fissure 1,500 feet below the surface of the vast plain that borders it, to the mouth of Rio Virgen; there it turns south, and moves onward to the junction of Rio Gila. Rio Verde takes its rise near the San Francisco mountains, and, flowing south through fetile valleys, joins the Salinas and unites with Rio Gila near the Coco Maricopa villages. The Gila forms the southern boundary of the area under consideration, which our line of survey intersects. It is traversed by several mountain chains of greater or less extent—of which the Hamook-häbî (Blue Ridge), Cerbat, Aquarius, Aztec, Black Forest, and Mogollon ranges are the principal—and dotted with many conical hills of volcanic origin. Between them are springs, streams, and valleys of considerable fertility.

The northern portion of this area is believed to be an elevated table-land of the new-red sandstone formation; with strata slightly dipping towards the north-northeast, forming a region nearly as barren and waterless, upon the surface, as the celebrated Llano Estacado. Captain Sitgreaves traversed it in 1852, and from Camp 21 to Camp 26, a distance of 75 or 80 miles, no water was found. Near the parallel of 35° 15′ the strata are broken; and south of that line the upper portions are swept away, exposing "magnesian limestone, sandstone of the coal measures, and the carboniferous limestone." Still farther south, "and especially at Pueblo creek, beds of old-red sandstone are seen below the lower carboniferous, and in contact with the gneiss and granite, similar to the old-red of the Catskill mountains."* Extending across this country, in a direction northeast and southwest, there is a series of volcanic cones indicating an axis of igneous eruptions. The San Francisco peaks, which are 5,000 feet above the base of the mountain, and 12,000 feet above the sea, appear to mark the point of greatest activity. Thence, the line of cones can be traced eastwardly across Flax river towards the Moqui country, and southwest so as to include Bill Williams' mountain, Mount Hope, in the Aztec range, and Mount Ives and Artillery Peak, upon Williams' river. Whatever may be the cause, the fact is evident that a large portion of the region south of the parallel of 35° 15′ is well watered and fertile; while that north of it is the reverse. Ruins of ancient pueblos and evidences of former cultivation are abundant throughout the valleys leading towards the Gila. The mountains and hills are covered with timber, the plains are variegated with patches of woodland and pasture, and the borders of the streams contain belts of arable soil. This country is capable of sustaining a considerable pastoral and agricultural population; and, probably, the mines of silver and gold reported by the Spaniards and Indians as existing in the San Francisco and other mountains in the vicinity, and of which we saw indications, will add inducements to its settlement.

West of the Aztec range the character of the country is considerably modified. The streams have generally a southwest course until they break through the beds of trap, lying upon the

* See the preliminary report of Jules Marcou, geologist to the expedition.

eastern slope of the Aquarius mountains, and join the main valley of Williams' river. North of White Cliff creek there are long, swelling slopes, peculiar to a granitic region, with two distinct ranges of mountains between Cactus Pass and Rio Colorado. These ranges extend nearly in a north and south direction, with broad depressions between them. The eastern terminates, or is broken, near the parallel of 35°, leaving between it and the northern point of the Cerbat range a wide opening. The western range, called Blue Ridge, or *Hamook-häbî*,* which borders the left bank of the Colorado, extends somewhat farther south; but gradually diminishes in height, and, near the latitude of the Mojave villages, is lost in an extensive prairie. Upon the east this prairie is bounded by the Cerbat range; and upon the south by numerous parallel chains of metamorphic mountains, through which Williams' river breaks in its course to the Colorado.

At the southeast point of the great bend of Williams' river is the junction of Rio Santa Maria, which appears to take its rise near a low depression in the Aztec range between Sierra Prieta and Mount Hope. It evidently drains a wide extent of country, the character of which is not known. Near its mouth it has a strip of valley with alluvial soil of apparent fertility. The sylva upon its banks are mezquites, mingled with cotton-wood trees.

From the Aztec range to the Aquarius mountains, the hills are covered with pine and cedar trees; and the plains, which are mainly formed by immense beds of trap, are clothed with a carpet of nutritious gramina. Most of the numerous rivulets which traverse this region, south of the latitude of Aztec Pass, form narrow cañons through the igneous rocks, and possess little soil capable of cultivation. Enclosed between the Aquarius and Cerbat ranges is the bed of Williams' river, which flows nearly south until it enters short cañons among metamorphic hills of the Cerbat range; it then turns westward, unites with the Santa Maria, and forces its way to the Colorado. The bottom-lands of the valley will average from half a mile to a mile in width, and the surface consists of alternate patches of sand and fertile soil. Groves of mezquite and cotton-wood, with dense thickets of willows, exist upon its banks, giving to this stream some of the characteristics belonging to the Gila. The hills that enclose it are generally barren of all useful vegetation, though diversified with numerous varieties of beautiful cactaceæ, rendering the scenery novel and picturesque.

From an examination of the observations made at numerous points of the survey, it now appears evident that gently sloping prairies extend continuously from the mouth of White Cliff creek around the northern extremity of the Cerbat range; and thence, sweeping slightly south for the purpose of avoiding the Blue Ridge, to the Mojave crossing of Rio Colorado. The distance for a railroad by that line would be about 70 miles. Grades of about 92 feet per mile could probably be obtained, with little expense for excavation or embankment. There is neither timber nor fuel in the vicinity; both would be brought from the Aztec and Aquarius mountains. Water is scarce; the Indians informed us of two springs only upon the route, which would make the distance from water to water about twenty-five miles. I do not know whether the substrata are such as to make it probable that water could be obtained at proper points by artesian borings; but a supply could doubtless be preserved by judiciously constructed tanks.

From our entrance to the valley of Rio Colorado Chiquito, or Flax river, its course is slightly north of west to Camp 82, a distance of about 35 miles; and the arable soil bordering it averages from one to two miles in width. The river is about 30 feet wide, flowing between alluvial banks eight to ten feet in height. The soil is generally light and porous, like that of Rio Gila.

* Mr. Blake has lately called my attention to the etymology of the word "Mojave." It appears to be formed of two Yuma words—hamook (three,) and häbî (mountains)—and designates the tribe of Indians which occupies a valley of the Colorado lying between three mountains. The ranges supposed to be referred to are: 1st, "The Needles," which terminates the valley upon the south, and is called Asientic-häbî, or first range; 2d, the heights that bound the right bank of the Colorado north of the Mojave villages, termed Havic-häbî, or second range; and, 3d, the Blue Ridge, extending along the left bank of the river, to which has been given the name of Hamook-häbî, or third range.

The banks of the main stream, as well as those of the numerous tributaries, are sprinkled with cotton-wood trees. Small groves of them occur at the junctions of these streams. Leroux's Fork is crossed near Camp 78. It is a rivulet of clear water about 20 feet wide, and densely wooded. Beyond, the valley is bordered with low, gravelly mesas, covered with a species of nutritious grass called grama, and has an elevation of about 50 feet above the river. The wagons frequently crossed spurs from them to avoid patches of soft earth in the bottoms. Between stations 3 and 4, a valley half a mile wide comes in from the northeast. At station 5, there is a branch from the north, with steep banks 10 feet in height. Between stations 5 and 6, sandstone bluffs, rising upon the right of the trail to the height of 150 feet, bound the valley, which is here one-third of a mile wide. Upon the opposite side of the river, near station 10, is the escarped edge of an elevated plain, extending south, apparently, to the Mogollon mountains. It is intersected by several tributaries. Between Camps 79 and 80, the river-bottom is in some places marshy, with willow thickets, and in others covered with a loose, pulverized soil. The south side of the valley appears to be in some places from two to two and a half miles wide. There is much marshy ground between Camps 80 and 81, which may be avoided by following the trail along the edge of the prairie slopes. Cottonwood Fork joins Flax river near station 2. The latter stream may be bridged at this place, or the line continued upon the north bank to the old Indian pueblo at Camp 82. Here the river is finely timbered with cotton-wood, and the south side of the wide valley contains traces of an ancient acequia.

At the point where the trail crosses the river, the stream is 50 feet wide, two and a half feet deep, and flows between clayey banks about 10 feet in height. A short distance below, it makes a bend and sweeps towards the north and northwest. To avoid this deflection, a reconnoissance was made in a direct line nearly west towards a low gap south of the San Francisco mountains.

Leaving the valley of Flax river a few miles below Camp 82, a low and narrow ridge was crossed, and a basin-like valley was entered, which, although containing no well defined stream, was said to be the outlet of Dry Fork. Having traversed this for about five miles, a gradual and almost imperceptible ascent led to a high prairie, somewhat cut up by gentle valleys, and dotted with isolated hills of sandstone, from 15 to 30 feet in height. Twenty-six miles from Camp 82 is the crossing of Cañon Diablo, which flows north in a chasm from 100 to 150 feet deep, and about 100 yards wide, cleft in a horizontal stratum of magnesian limestone. Thence to station 4, between Camps 89 and 90, the general surface of the intermediate country is a plain, sloping towards the east with an inclination of 40 feet per mile. It is, however, traversed by several ravines, occasionally forming small cañons; but they interpose no serious obstacle to the construction of a railway across this section. There is water in Cañon Diablo, and at the Conino caves, near this line; probably it could be found at other intermediate points. Cedar trees are scattered along the trail between Dry Fork and Cañon Diablo. Dense thickets commence a short distance further west; and, upon reaching the vicinity of the Conino caves, they give place to forests of magnificent pines.

From the base of the San Francisco peaks, many wide valleys, bounded by heavily timbered hills, extend towards the branches of Cañon Diablo and Flax river. Station 4 is upon the northern edge of one of the former, called Pine valley, which has a breadth of about five or six miles. The trail ascends its smooth, grassy slope. At station 6 the valley is several miles wide; at station 9, it unites with a broad, open prairie, bordered with pine forests, and extending towards the northwest to the foot of the steep mountain slopes. Continuing up this valley towards the southwest, at station D we reach the summit of a low ridge between the San Francisco mountains and a long spur from the Sierra Mogollon, which divides the waters of the Colorado Chiquito from Rio Verde. The ascent to this point is remarkably uniform; and the deep depression which here exists between the mountains is about a mile in width, and so gentle in its declivities as to render it difficult to define the exact position of the dividing crest. Superb forests cover the slopes of the mountains upon each side. The maximum grade through this

pass—according to the profile—is 85 feet per mile; and an excavation would be required at the summit. Thence to Camp 90, the descent would not be difficult with moderate grades.

From Camp 90 to station 5, the line continues upon the edge of the pine forest overlooking the immense valley of Rio Verde. This stream heads in various ravines formed by spurs from the San Francisco mountains. The southeastern terminus of this range, or rather mass of mountains, is a huge pile of granite, rising abruptly upon the right of the trail to the height of about 2,500 feet. To the northwest, several volcanic peaks appear, elevated 5,000 feet above the base. Crossing the low spur upon which station 7 is situated, we enter another branch of the valley, and at station 13 reach the springs of San Francisco. Water is abundant here, and it flows in a small stream southward to the Rio Verde. From these springs we pass a slight ascent, and enter a dry cañon, the narrowest part of which (about 100 feet) was plentifully strewed with boulders broken from the cliffs. From this point the trail ascended the bank, about 200 feet in height, and, having crossed an undulating surface, re-entered the valley at station 9. Thence to Camp 91 there is a broad valley the whole way, and at the head of it is Leroux's spring, where a stream of clear water gushes from the hill-side. Its temperature, December 29, at sunrise, was 48.4° Fahrenheit; that of the atmosphere at the same time being 37°.5. Large pine and spruce trees grow in the ravines and upon the sides of the mountains; and extensive forests of different varieties of good timber cover the vast plains and valleys that slope toward the south. With regard to the construction of a railroad from Camp 90 to Camp 91, no difficulties were presented to the eye, except for a short distance through the cañon referred to. The reduction of the notes of survey, however, leads to conclusions less satisfactory than had been anticipated; and, unless some error has crept into the work, the maximum grade will exceed 90 feet per mile, and the labor of graduation will be great. To avoid these objections a more southerly course across branches of Rio Verde has been recommended.

Leaving Leroux's spring, and the fertile basin which it irrigates, the trail crosses a slight ridge* north of Triangulation hill, traverses a forest of yellow pines and long, grassy plains to New Year's spring, at Camp 94. A secondary range extends towards the west, from the San Francisco peaks, and, two or three miles distant from the trail upon the right, contains several peaks from 2,000 to 2,500 feet above the plains at their southern bases.

Nearly south-southwest from New Year's spring is Bill Williams' mountain, about 10 miles distant, whose peaks are above 3,000 feet high. The intermediate country has a generally level surface, divided into woodland and prairie. The hill-slopes are covered with pine timber.

One mile east from New Year's spring there is a hill about 200 feet high, from the top of which is obtained an extensive view of the surrounding country. Towards the north and north-northwest appears an elevated plain, looking bleak, waterless and barren. It is dotted with conical hills of black volcanic rock. In a west-northwest direction, a broad open valley, dark with the foliage of cedar forests, extends to the mountains of La Laja, and for some distance is bounded upon the southwest by a low range of hills covered with trees excellent for timber. Towards the south-southwest lies the volcanic pile of mountains called "Bill Williams'," west of which is a succession of valleys and plains extending about 30 miles from New Year's spring to a conspicuous peak known as Picacho. This is the southern terminus of the range of La Laja; and at its base Partridge creek, which drains the intermediate country, empties into *Val de China*. The triangular space included between New Year's spring, Bill Williams' mountain, and Picacho, has the general appearance of a vast plain sloping gently to the southwest; examined more minutely, it is dotted with small hills and traversed by valleys, which in a few places are contracted, and enclosed by low walls forming cañons. There is good pine timber in

*A reduction of the reading of the barometer at noon upon the summit of this ridge makes its altitude 204 feet above Leroux's spring. Mr. Campbell agrees with me in the opinion that it is too great. This appears to be one of the errors which will be found referred to in the subsequent "Remarks upon the profile." It is consequent to the application of the formula for correction due to mid-day air temperatures. The effect is, as there stated, to give a roughness to the profile, and heavier grades than the surface of the country requires.

the vicinity of New Year's spring, and also in the region of Bill Williams' mountain. East of Val de China lies an extensive tract covered with large cedars and piñons, forming the so called Black Forest.

It may be seen from the profile, that, by the trail from the San Francisco springs to Picacho, the route is not impracticable for a railroad. The conformation of the country south of that line, however, is such as to lead to the belief that, by crossing the head branches of Rio Verde south of Bill Williams' mountain, traversing the Black Forest, and entering Val de China near the mouth of Pueblo creek, we would avoid the ascent above the San Francisco springs, entirely dispense with the most elevated summit upon the route, and shorten the distance to Aztec Pass without increasing the grades or expense per mile for graduation. Many questions regarding similar deviations from the line are to be determined by more elaborate surveys.

A semi-circular range of hills extends from the San Francisco peaks to Bill Williams' mountain, forming the northern and eastern boundary of the flat prairie and forest basin, which has been described. Near New Year's spring there is a wide gap in it, where the ridge is almost inappreciable. From this point a low spur extends west and west-northwest to the mountains of La Laja; dividing the water courses which drain northwest, through Park valley, from those that flow, by various branches of Partridge creek, into Val de China. From the examinations made, it was found easy to pass down the southern slope of this ridge into the valley of an eastern branch of Partridge creek. By some mistake, however, attributed to the intricacies of the numerous ravines, and the thickets of trees that cover much of this region, the train and the main survey followed, for a considerable distance, the northern base of the ridge, and beyond Camp 95 crossed over to Partridge creek. The more minute topography is, therefore, upon this line.

New Year's spring, at Camp 94, is at the head of one of the branches of Park valley. It is surrounded by a grove of pine trees, from 125 to 150 feet in height. Leaving the spring, we ascend the low prairie ridge and take a westerly course over a surface that, at a distance, appears level; but is found to be considerably broken by ravines, some of them from 30 to 50 feet in depth. The first contained pools of water. Station 1 is in Park valley, which, covered with cedar trees, extends like a broad plain towards the northwest, with the view uninterrupted almost to the horizon. Savedra made an exploration across this valley, and was absent three days without finding water. Again rising to the prairie at station B, we were about half a mile from the most northerly peak of Bill Williams' mountain, which is about 500 feet in height. To our right, between stations 3 and 4, there is a valley; and from 4 to 7 the trail is parallel to it. Between stations 8 and 9 we crossed a cañon, and at station 10 entered another; both of which incline to the right. Passing onward to Lava creek, we found a magnificent pool of water, and encamped. The soil of the prairies, though covered with excellent grama, is somewhat sandy, and overlies beds of lava or trap. The rock is exposed upon the sides of the cañons. Even the valleys have little depth of soil, and are uncultivable. Pine trees cover the hills and extend along the valleys. The grade for a road need not exceed 55 feet per mile. The ravines would be difficult to cross, but by keeping more to the left, most of them could be headed.

From Camp 95 to station 4, the trail descends to a broad cañon, about one-fourth of a mile wide at top, and the banks 75 feet in height. Near stations 7 and 8 are large piles of naked lava. The pines have now given place to cedars, which cover the slopes in every direction. Passing a slight elevation, we entered another valley, which, as we advanced, grew narrow, and between stations 8 and 9 formed a rocky ravine. We ascended the side slopes 135 feet to station B, which is upon the crest of a high ridge covered with cedar and piñon trees. It is composed of sandstone and carboniferous limestone, and extends far towards the right with a regular slope. About three or four miles beyond, there is a similar and parallel range of hills; and, between, lies a wide valley, densely wooded, and called—perhaps improperly, for we found no water in it—Cedar creek. From station B the descent for about 200 feet was at an inclination of nearly 45°; thence to station 13, two miles, 280 feet; and from that point, one mi[l]

a third, to Camp 96, in the bottom of the valley, 160 feet. This ridge would be impracticable for a railroad, except for the smoothness, regularity, and extent of its western slope. From an examination of the ground, it would appear practicable to cut through the crest at the gorge referred to, and construct a road upon the side slope, with a grade of about 75 feet per mile. This would enable us to strike the trail at station 14, between Camps 96 and 97.

From Camp 96 we followed the valley, which between stations 1 and 2 is contracted to the width of 150 yards, with banks from 20 to 30 feet in height. Beyond, the slopes upon the left are gentle; and at station 5 a wide branch of the valley comes in from the south. Three miles to the right of station A is the continuation of the bluffs, crossed at station B, between Camps 95 and 96; and they continue far towards the west-northwest. The valley between is dotted with knolls and sprinkled with cedar thickets. The surface is smooth and covered with grass. A quarter of a mile to the right of station 13 there is a hill 200 feet high. The slopes to the right are very gentle; the surface is prairie, with few trees. Upon the hill-sides, to the right of stations 14 and 15, much red sandstone appears. Here we passed a low dividing ridge, and entered the valley of Partridge creek—high hills continuing upon the right of the trail. Beyond, the valley becomes narrow, and at length enters a cañon of Partridge creek, with high bluff banks, which are covered with cedar trees. The trail followed the undulating slopes upon its borders to Camp 97, situated within a rocky glen, where the creek contained large pools of water. The geological outcrops are of the lower carboniferous formation. The country passed over is rough, but the general slopes are favorable for a roadway. From station 14 to Camp 97 the maximum grade may amount to 80 or 90 feet per mile.

From Camp 97 to Camp 98 the route lies near the cañon of Partridge creek. Its steep banks are from 50 to 80 feet in height, varying from one to three hundred yards in width. The top of the bluffs, though broken and rough, are upon a level with the general surface of the country, and, for a road, the labor of graduation would be less at some distance from the creek. The stream is not flowing, but it contains numerous pools of water. Grass and trees are abundant upon the trail. There is but little arable soil in the vicinity.

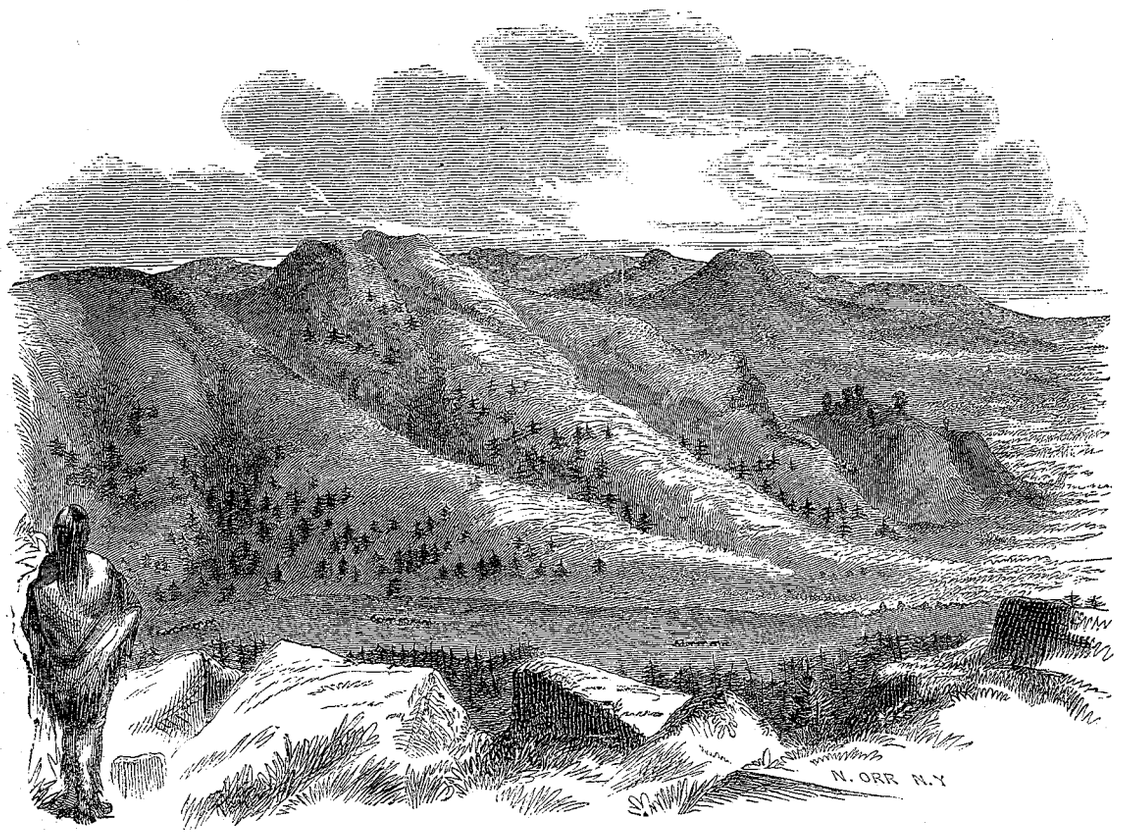
From Camp 98 to station 5, the trail follows the bed of the cañon. At that point the banks recede, leaving a good-sized valley between. The stream, however, makes a large bend toward the southeast; and, to avoid it, the line of survey took a direct course southwest across the nearly level prairie toward Picacho. Between stations 9 and 10 is a dry arroyo leading to Partridge creek. The ridge of Black Forest appears about fifteen miles to the left. Another chain of hills lies upon the right, about ten miles distant. From station 10 to 14 the country is level, producing a few scattered cedar trees; thence to Camp 99, the trail crossed a rolling prairie, intersected by a number of deep ravines, in which water was found. About three miles to the northwest is Picacho, with a gravelly spur extending to the vicinity of camp, and forming the southern terminus of the range of La Laja; the Black Forest range, from the south-southeast, ends about two miles southeast from the same point, leaving between the two ranges an opening through which Partridge creek flows into the great Val de China. The bed of this valley is about 200 feet below the general surface of the prairie, which borders Partridge creek, and ends in a bluff below Camp 99. Camp 100 is situated at the foot of it, about one mile distant from, and 188 feet below, Camp 99. By following Partridge creek from Camp 98 to its entrance to Val de China, the grades would be light. It would, probably, be equally practicable to construct a road along the trail, from station 5 to station 15—between Camps 98 and 99—and there entering a ravine, follow it to the confluence with Val de China, near Camp 100. The gradients would be favorable, except upon the latter portion, where they might amount to eighty feet per mile. The direct route from New Year's spring, referred to in the general description of this region, would take the northeast branch of Partridge creek, and unite with the survey near Camp 100.

Between Camps 100 and 101, a distance of seven and a half miles, the trail passes across the rich bottom-lands of Val de China, in a southwest course, nearly perpendicular to the general direction of the valley at this point. The country is smooth enough for the laying of tracks

for a road upon the surface. There are a few water-worn channels, which would be crossed by culverts or short bridges.

From Camp 101 the course of the trail is south-southwest, toward Mount Hope. Upon the right is the northern part of the Aztec range of mountains, and from the base of its steep sides low spurs of hills extend westwardly, gradually sloping to the edge of Val de China. Through these hills, which are covered with cedar trees, the trail ascends the gentle slope of a small ravine to its head near station 5. Thence it passes a low ridge and enters a small valley, with rich alluvial soil, through which flows a pretty rivulet called Turkey creek. Amidst a grove of oak and walnut timber is Camp 102. From Camp 102 to Camp 103 another spur of hills is crossed, which separates Turkey creek from Pueblo creek. The latter stream heads at Aztec Pass and flows easterly through a wide and deep ravine, dividing this range of mountains into two portions; the northern being horizontally stratified, the southern disturbed and changed by subterranean heat. From the foot of the cliffs upon the north to the bed of the rivulet, the slopes are regular, affording a side location for a railway, with favorable grades around the southeastern and southern declivities, from the ridge near Turkey creek to Aztec Pass; thus avoiding the descent to Camp 103 upon Pueblo creek. There is considerable arable soil upon this stream, and in the vicinity a variety of sylva. The mountains are covered with pine timber; the living streams are bordered with oak, cotton-wood, walnut, or ash, and the hills yield a dense growth of cedars.

Aztec Pass is between Camps 104 and 105. It is upon the top of a low granitic spur, which



View of Aztec Pass from the Indian ruins, looking south.

seems to connect the northern with the southern portion of the Aztec range. At its junction with the steep slopes of the southern peaks, two water-courses are formed. The eastern falls down a steep ravine, half a mile to the foot of the hill, and then, joined by a ravine from the

north, forms the head of Pueblo creek. The second follows the gentle slope of a wide and smooth valley towards the west-northwest, and becomes tributary to Williams' river.

The accompanying sketch, taken from the ancient ruins that crown a height upon the north, overlooking the pass, represents the summit of the dividing ridge and the prolongation of the Aztec range towards the south. In the distance, upon the left, is seen the top of Mount Hope, and the Gemini mountain is shown upon the right. From the latter extends a sloping plain to the wide valley in which Williams' river takes its rise.

The difficulty in constructing a railroad through this pass consists in the high embankment that would be required to cross the northerly ravine above referred to. With a cut, about 40 feet deep at the summit, the excavation and embankment would be nearly equal, and the gradients probably would not exceed 50 feet per mile. Having accomplished the passage of the summit, the descent would be easy down the wide valley through which the trail follows, to Camp 105. Below, upon the banks of the same rivulet, Camp 106 is situated. A small stream threads the valley and is occasionally lost beneath the surface. But few trees line its banks, though pines abound in ravines among the mountains, and cedars are plenty upon the hill-slopes and upon the plains adjoining.

From Camp 106, the trail follows the valley, in which there are a few small cañons cut through beds of lava. The soil is a sandy loam, producing good grass. Two miles distant upon the left, there is a ridge of hills bordering the valley. Station 3 is in the bed of a ravine containing water. From station 3 to station 4, the valley is several miles wide. The slopes of the hills upon the right are regular; while, upon the left, the country is rocky and broken. A low ridge, which, extending from the Gemini mountains, turns the valley towards the north, was crossed at station 7. Thence, passing a gently undulating prairie, sprinkled with occasional thickets of cedars, we struck the stream again at Camp 107, where it has high bluff banks. A short distance below, a chasm is formed; width about 80 feet, and height of rocky sides from 60 to 100 feet. There is water in the bed of the stream, and cedar trees upon the banks. The railroad line from Camp 106 would follow the valley of the stream, making a bend towards the north, and thus avoid crossing the cañon.

From Camp 107 to station A, the ascent is not difficult. Thence, attempting to descend along the bank of the stream, a deep ravine was crossed. One mile to the right of the trail, there extends a ridge of hills belonging to the Aquarius mountains. The general surface of the country is an undulating prairie; the soil containing much clay and loam. The prevailing rocks are granite and trap, which are so much cut up into chasms as to make the passage with wagons difficult. Hence the train returned; and Camp 108 was formed at station A, in the immediate vicinity of Camp 107. A reconnoitring party, however, pursued the course of the stream some miles further, and then passed northerly over the slopes of the Aquarius range, to White Cliff creek, which was followed to its junction with Big Sandy.

From Camp 108 to station A, the surface is somewhat broken. A small stream crosses the trail between stations 1 and 2, and another between stations 5 and 6; both evidently branches of White Cliff creek. From station 3 to station 7, the surface continues undulating; although the general slope is quite uniform, and from a slight eminence appears level. From station 7 to E, between stations 10 and 11, the trail passes over low ridges which divide ravines that have a southerly direction. Upon the right, three miles distant, there is a range of hills 400 feet high. To the left of station 9 there is a large valley, supposed to contain the main branch of White Cliff creek; and from station E to Camp 109 the ground is furrowed by various ravines, apparently tributaries to that stream. North of camp are rocky hills, covered with cedars. There is a chain of highlands also upon the left. The profile, from Camp 108, is projected south of the trail, along the valley noticed above.

The rivulet is rocky in the vicinity of Camp 109. The trail toward the west-northwest crosses several small valleys which extend southwest among small ridges, peaks, and mesas. From station 2 to station 3 the surface is level. Near station 4 the dry bed of a stream

is crossed. From camp to station A, between stations 6 and 7, the ascent is nearly continuous. There is a steep descent into a cañon from station 8 to station 9; and the trail from stations 9 to 15 is in the dry bed of a tributary to White Cliff creek. Passing into another branch at station 16, the trail then ascends its valley to Camp 110, near Cactus Pass. There is water in this branch of the creek, and cedar trees are still abundant upon all the hill-slopes in the vicinity. Cactus Pass is not practicable for the location of a railway; and it is proposed to make the profile for that line, as before stated, from Camp 108 down the valley of White Cliff creek. Measurements for that purpose were made upon a reconnoissance, and will be referred to hereafter.

Cactus Pass is formed by a deep gorge in a high range of granitic mountains. From the summit, about 300 feet above the pass, an extensive panoramic view is obtained. The Hamookhäbî, or Blue Ridge, is seen bordering the Colorado, and a lesser range intermediate. The latter terminates nearly in the latitude of this place, and, after an intervening gap, the Cerbat range is prolonged in the same southerly direction. Toward the northwest there is a vast plain, leading apparently to Yampa creek, and bounded upon the east by broken ranges of low mountains. East of the Cactus mountains may be seen the extensive broken plains already traversed—Cross mountain, 800 feet high, and the Aquarius range, 1,000 feet high, being the principal of the peaks and ranges that break the general level of its surface.

The ascent from Camp 110 to station 1, at the summit of Cactus Pass, is about 100 feet in little more than half a mile. Thence, down the first portion of the ravine, the declivity is nearly precipitous, and in one mile and three-quarters, to station 3, the descent is 830 feet. Here the valley becomes wide and sandy, and the trail keeps to the left of it, crossing a gently swelling slope that comes down from a southerly spur of the Cactus mountains. Near station 5 there are springs, in the vicinity of which the reconnoitring party bivouacked, January 28.

Station 6 is 560 feet below station 3. Thence to Camp 111, near the mouth of White Cliff creek, the descent is 350 feet more; making a total, from Cactus Pass, of 1,640 feet in a distance of eight miles. White Cliff creek is a clear and rapid stream, with a strip of fertile soil upon its banks for eight or nine miles up the valley, to the bivouac of the exploring party, January 27. Its principal tributary is about four miles below that point, and both streams are bordered by a dense growth of cotton-wood. The altitude of the bivouac, from the readings of the barometers, is 4,480 feet, or 950 feet above Camp 111; giving the descent of the stream above 100 feet per mile. But, as it contained no steep rapids, to the eye the declivity seemed much less, and possibly an error may have been made in the record of the observations. The distance from the bivouac to Camp 108, near the head of this stream, is about 8.5 miles; and the altitude of that camp being 4,814 feet, the fall of the rivulet between those points would be nearly forty feet per mile. Its valley, with the deflection indicated upon the profile from Camp 108 to Camp 111, may be considered practicable for the location of the railroad line. White Cliff creek is bounded upon the north by high gravelly slopes and mesas, which terminate the mountain spur south of Cactus Pass. It is therefore believed feasible to locate the line upon this ridge, so as to turn the southwest point of the high mountains, and avoid the descent to the bed of the lower portion of the creek. This line would strike the trail, from Camp 110 to 111, at station 9; which, being about 200 feet above the latter camp, would cause an improvement in the grade. Station 9 is in a valley leading, by a gentle ascent, to the wide prairie which has been described as seen from Cactus Pass. It is apparently nearly level to the gap north of the Cerbat range, and thence inclines, by broad slopes, to the Colorado river. From an examination of our topographical sketches and views, and a comparison with the heights of relative points, both upon our own exploration and upon that of Captain Stitgreaves, the elevation of the gap is estimated at 3,900 feet above the sea; giving for the ascent, from Camp 111, 374 feet, and an ascending grade of 11.5 feet per mile. From this summit a broad plain slopes the Colorado river, and a spur of it impinges upon that stream between the mountain ridge, alled "The Needles," and the Mojave villages. The elevation of the bluff is 450 feet above

the sea, and the descent from the pass is 3,450 feet. The distance in nearly a straight line is 37.4 miles, and the grade, if uniform, as the appearance of the country seems to indicate, would be 92.4 feet per mile. The sketch No. 3, taken from the right bank of Rio Colorado, looking east, gives a view of the country here described.

The region which includes the Cactus and Aquarius mountains is well supplied with cedar trees. Westward the sharp-crested ridges appear naked, and the plains nearly destitute of foliage. Wood is scarce, even for fuel. The two Indian springs, already referred to as existing upon this route, probably indicate points where, by digging, a sufficiency of water would be found.

From White Cliff creek to the Mojave crossing of Rio Colorado, our wagon trail followed Big Sandy creek, Williams' river, and the valley of the Colorado. For a description of the topography upon this part of the route I would refer to the Itinerary. Although meagre in its details, it may suffice to give a general idea of the character of those streams.

SECTION VII.

From Rio Colorado to the Pacific.

The lofty crest of the Sierra Nevada, which forms the distinguishing topographical feature of California, extends uninterruptedly through five degrees of latitude, from Madeline Pass on the north, to Walker's Pass on the south, the latter being in latitude 35° 40′. Between these points, it appears to be conceded that there is no break in the chain available for a railroad route. A secondary range of mountains, called the Coast range, dividing the waters of the Salinas from those of the San Joaquin, extends southeast from Monte Diablo to a point southwest from Walker's Pass; where, in latitude 34° 30′ about, it intersects with a third great range. The latter commences at Point Conception, and extends* east-southeast to San Bernardino; and thence, according to recent explorations, is prolonged to the Colorado, near the junction of Rio Gila, and forms the northeast boundary of the California desert. South of San Bernardino commences another system of mountains, which traverses the whole length of Lower California. These various ranges are all united by low hills and ridges that are confined to a belt, about a degree and a half in width, bounded on the north by the parallel of 35° 15′, and upon the south by latitude 33° 45′; and among these connecting links are to be found the few available passes leading from the Colorado river to Los Angeles or San Francisco.

The vapors that rise from the coast are generally precipitated upon the western slopes of the mountain ranges referred to; and therefore, south of the parallel of 36°, there is no stream, worthy of note, flowing from their bases eastward, save the Mojave river. This stream was formerly supposed to empty into the Colorado, near the Mojave villages; and, when our survey was projected, we believed it would lead by a favorable course the whole distance from that place to the eastern base of the Sierra Nevada. It now appears, however, from the examinations of Lieutenant Williamson—and subsequently those of Lieutenant Parke—that the Mojave river is lost at Soda lake. Hence, the region it traverses forms a basin belonging to the same system as those that are so celebrated further north. It is separated from the valley of Rio Colorado by a wide granitic mass, called the Painte mountain, which seems to be a prolongation of the Wasatch range. The slopes upon the east are so regular and smooth as to appear like a nearly level plain. Upon the summit there are but a few crested ridges, and the topographical sketches show passes, north and south of our line, lower than that upon which the levels were taken. It is believed that a more extensive exploration would discover a route across this ridge, by which the grades to Soda lake would not exceed 80 feet per mile.

The region in the vicinity of the junction of the great mountain ranges that bound the Pacific slopes of California, within the belt above referred to, was explored by Lieutenant Williamson; and the passes which he surveyed are described in his report. I beg leave briefly to refer to a few of them, as they have an important bearing upon the termination of the route under consideration.

The best of the passes examined by Mr. Williamson are the San Gorgonio, at the junction of the Lower California range of mountains with the San Bernardino range; New Pass, through the latter range; and Taheechaypah Pass, through the ridge dividing the so-called Great Basin from the head of Tulare valley. San Gorgonio Pass is available only to connect the Gila route with Los Angeles or San Diego. In the prolongation of this line to San Francisco, it is neces-

* This general sketch does not refer to the geological divisions, or strike of the mountain ranges, but simply, the direction of the masses.

sary to thread both of the other passes mentioned. The latter—the Taheechaypah—is in latitude 35° 7′, and from its summit, slopes of gentle inclination lead eastwardly across the Great Basin to the northwest bend of the Mojave river. In this consists one of the advantages of the route by the 35th parallel, viz: that by a single pass—the most available known—the Cordilleras of California are surmounted, and San Francisco reached with the least practicable deviation from a straight line. Therefore, we are enabled to adopt San Francisco as the termination of this route, and to disregard the difficulties which would have been encountered at Cajon Pass in obtaining an entrance to the valley of Los Angeles.

The central portion of the region embraced in this section of our route is noted for barrenness. Some of the soil possesses the elements of fertility, but vegetable growth is prevented by the want of moisture. As before stated, the vapor rising from the Pacific is generally precipitated upon the western slopes of the mountain chains that traverse the State of California, nearly parallel to the coast. At their eastern bases are found a few springs, and small streams flowing towards the desert; but, excepting the Mojave, they disappear at a short distance from their sources. Between the mountains and the Colorado the climate is dry; the winds parch the earth, and the soil is arid. No part of our country has a wider celebrity for barrenness than that known as the Californian desert, between Cariso creek and Rio Colorado. Until the autumn of 1849, it was found to be a sandy and dreary jornada, without water or grass for about 80 miles, causing great suffering to the overland emigrants who attempted to cross it. Then, suddenly, water appeared in various lagunas and channels; and in a few weeks the central portion of this desert was covered with large fields of luxuriant grass. The water was probably backed up by a strong south wind upon the Gulf, and a simultaneous rise of the Colorado river had the effect of irrigating the soil of the desert basin. At length, by evaporation and absorption, the water disappeared; and a spot that had given evidence of remarkable fertility became naked as before, without the faintest trace of vegetation.

There are peculiarities in the conformation of the country, near the parallel of 35°, requiring some modification of the general characteristics above described. The sudden breaking down of the Sierra Nevada, near that latitude, probably allows a passage for a portion of the moist air from the coast, sufficient to nourish nutritious grasses upon the prairie slopes, and, by precipitation upon the San Bernardino range, to feed the Mojave river. Upon the elevated ridge between Soda lake and the Colorado, there is also a deposition of moisture sufficient to sustain a few small springs, and give sustenance to grama grass upon its broad slopes. The Mojave river, from its source to the entrance into the basin of Soda lake, irrigates a valley which contains a belt of arable soil. From that point to the western slope of the Paiute mountains, with the exception of a narrow space in the vicinity of the lake, the country is sandy and barren, possessing all the characteristics of a desert.

The valley of Rio Colorado affords a large extent of fertile bottom-land which may be irrigated and cultivated. The soil is believed to be superior to that of the Rio Grande. Large patches of it are cultivated by Indians, producing crops of maize, wheat, beans, melons, and squashes.

As artificial irrigation seems to have been but little resorted to by the natives in their system of agriculture, it may be inferred that there is much moisture in the atmosphere, or that summer rains are more frequent here than in New Mexico. With a suitable system of acequias, or drains from the river, to water the soil, this valley would doubtless be as well adapted for the production of tobacco and cotton as the bottom-lands of Rio Gila, near the Pimo villages. The southern portion seems favorable for the production of rice and sugar.

The amount of arable land upon the Colorado, between the parallel of 35° and the junction of Rio Gila, is roughly estimated at 700 square miles. This estimate is based, partly upon our own observations, but mainly upon the results of Captain Sitgreaves' survey, with measurements taken from his map, and is made up as follows, viz: the Mojave valley, forty miles in length, averaging four miles in width, equal to 160 square miles; the Chemehuevis valley, eight miles in length, averaging four miles in width, equal to thirty-two square miles; the

valley at the mouth of Williams' river, eight miles in length, averaging three miles in width, equal to twenty-four square miles; the Yuma valley, forty miles in length, averaging eight miles in width, equal to 320 miles; the Cuchan valley, eighteen miles in length, averaging three and a half miles in width, equal to sixty-three square miles; the valley of Caballo en Pelo, above the junction of the Rio Gila, ten miles in length, averaging eight miles in width, equal to eighty square miles; other portions of the stream being bordered by narrow belts of good soil, sufficient, probably, to make up the amount stated above. Below the mouth of Rio Gila the bottom-lands that may be irrigated are very extensive.

The Colorado river, at the crossing near the Mojave villages, was divided by an island into two channels; one about seven feet, the other ten feet in depth. From that place to the mouth of Williams' river—a distance of fifty-two miles—the inclination of the stream is 1.6 foot per mile; and there is no appearance of shallows, rapids, or other obstructions to navigation. Between the mouth of Williams' river—the computed elevation of which is 356.4 feet above the sea—and Fort Yuma, 150 miles, the slope of the valley is believed to remain nearly the same, giving to the Colorado similar characteristics to those above described. Assuming the fall of the river to be 1.6 foot per mile, the altitude of the river at Fort Yuma would become 116.4 feet above the sea; and thence to tide-water of the Gulf, 80 miles, the descent would be nearly 1.5 foot per mile. Steamboats from the Pacific have long navigated the Gulf of California and the Colorado river to Fort Yuma, for the purpose of conveying supplies to that military post. From all that is known of this river, there seems to be sufficient reason for believing that the same vessels of light draught might navigate the channel for the remaining 200 miles to the Mojave villages. The whole distance, from shore to shore, at the ferry above referred to, is about 1,800 feet—more than twice the width of the river at the upper or lower end of the Mojave valley. Near the middle of the river, separating the stream into two channels, there is an island of sand 200 yards wide, and about a quarter of a mile in length. For the location of a bridge, however, a more favorable point is found near Camp 132, where gentle slopes of the prairie form low bluffs impinging upon the river. From the east, this point may be approached by the route around the northern base of the Cerbat range; and upon the west the line would edge along prairie slopes to the Sacramento springs. Our trail, from Camp 134, was across the fertile bottom lands upon the right bank of the Colorado, and thence along the base of the gravelly spur which borders it. Camp 135 was formed upon an arm of the river, which encloses a wide marsh covered with rushes. Upon the eastern side of the valley, parallel to our trail, there exists a broad ridge of mountains, limiting the width of the arable soil between its base and the river to about ten miles. The trees upon the stream are principally mezquite and cotton-wood.

A short distance above Camp 135, a valley, from the W.N.W., unites with the Colorado. It contains the sandy bed of a stream which heretofore has been supposed to be Mojave river. Our trail, leaving the Colorado valley near the last mentioned Camp, crossed a gravelly spur 80 feet in height, and entered the arroyo at station 2. A short range of high hills upon the north terminates near station 3, and the valley sweeps around its western and southern bases. There is a similar highland range upon the south about eight miles distant. Toward the west appears a broad ascending plain, without any visible crest surmounting it, but traversed by a ravine, which the trail ascends to station 4. Here it is bordered by a few small hills whose bases are composed of beds of marl containing several springs of water. They are about ten miles, in a straight line, from the Colorado, and nearly 800 feet above it.

A view of this region was sketched from the left bank of the Colorado, looking W.N.W. It is represented in plate No. 1, and prefixed to the Itinerary. Plate No. 2, taken from the island in the Colorado, and giving the view looking north, precedes the topographical report. Plate No. 3, representing the right bank of the Colorado, looking east, or E.S.E., will accompany the Indian report. The three landscapes differ with respect to their foregrounds, but the spaces between the points of view are so small that the distant scenery is scarcely affected thereby. They may therefore be united, for the purpose of showing the character of the moun-

tain ranges, and thus a panoramic view will be obtained, covering an angle of 180°, from the W.N.W., by the north, to the E.S.E. No. 3 shows the plain by which it is proposed to descend to the Colorado valley from the east. No. 1 gives a view of the pass through which the Mojave river was previously supposed to flow, and by which the profile crosses the mountain ridge, separating the Colorado valley from Soda lake.

From the Sacramento springs the trail takes a northerly course, following prairie slopes upon the western edge of the valley, which is from five to ten miles in width. Upon the left there is a slight ridge, with several openings for sandy arroyos, perpendicular to the trail, showing channels for the drainage of the waters of the plains beyond. Upon one of these ravines is Camp 136, about twenty-one miles from the river, and 1,700 feet above it; the grades being nearly uniform. The whole country traversed since leaving the Colorado valley—except at the springs above noticed, where are patches of grass—is nearly destitute of vegetation. Chamiza upon the plains, and a few yuccas near the arroyos, furnish a scanty pittance of food for the animals and fuel for camp-fires.

From Camp 136 the route continues nearly north to station 2. Upon the left is a range of hills, 800 feet above the trail and 1,500 feet above the valley, at the foot of the wide slopes upon the right. At station 2 this range is broken, leaving an opening towards the west two and a half miles in width. Thence we approach the base of a cluster of sharp crested hills, from 800 to 900 feet in height, at the rocky base of which flows a rivulet called Paiute creek. Upon its borders, near Camp 137, are patches of fertile soil, which have been cultivated by Indians, producing corn and melons. There are cedar trees and grass upon the hill sides. The stream flows S.E., and is probably lost in the valley before mentioned, which, sweeping around the northeastern base of the mountain, continues south and east to the Colorado. The ascent from Camp 136—about 600 feet in nine miles—has been gradual, except near the entrance to the creek, where several rough ravines were crossed.

From Camp 137 the trail ascended a tortuous ravine to the head of one of the branches of Paiute creek, and then mounted to the crest of the ridge at station 2, about 830 feet above the cultivated fields in the valley. From this point sketches were taken, showing a wide gap between the hills upon the left, and upon the right a low valley, three-quarters of a mile wide, appearing to drain the waters of the plain, which lay extended towards the west, into the same great valley that receives Paiute creek. Station B is at the western base of the ridge. From that point the course of the trail is nearly magnetic west across a vast plain extending about twenty miles to Camp 39 at Rock Spring. The ascent is uniform, at an inclination of about eighty feet per mile. Grama grass abounds throughout its whole extent, and upon the sandy arroyos, which traverse it, there are fringes of cedar trees furnishing fuel. Rock Spring issues from a deep ravine, the sides of which are composed of ledges of sienite. A few hundred yards below, it flows into a large valley that proceeds from the N.W. to the S.E. toward the Sacramento springs. Toward the south, 15 to 30 miles distant, are noted two short ranges of mountains; and between them and the trail the sketches indicate a broad valley, judged to be one thousand feet lower than the region passed over. Near the camp are several rocky hills, covered with cedar trees, and containing good grass upon their slopes.

Leaving Rock Spring we pass around the northern base of the sienitic hill, and make a gradual ascent of 300 feet in 3 miles, which brings us to station 5, upon the summit of the Paiute ridge. Before us appears a gap between two elevated crests—one upon the north, the other upon the south—and a ravine with a well-defined water-course westward. The rise to this summit from the east is nearly uniform for 25 miles. Little cutting, therefore, would be required to construct a road of a grade from 80 to 100 feet per mile upon the natural inclination of the surface. It would be difficult to diminish the grades, except by winding in a serpentine course across the wide plains, so as to increase the distance. The mountains upon each side of the pass are from one to two miles distant, 600 or 700 feet in height, and are covered with cedar trees and a few pines. The arroyo bends between stations 5 and 6, inclining gently toward the

west. At station 6, about 2 miles west of and 40 feet below station 5, the width between bluff banks is a quarter of a mile. From this point the ravine becomes abrupt, descending the western slope of the mountain-ridge with a rapid declivity to a broad valley which sweeps from the north, and turning the S.E. base of Marl hill, leads between sandy slopes to Soda lake. From station 6 to station A, where the trail intersects the Sand-hill valley, the distance is seven and a half miles, and the descent 1,538 feet. The crest of the mountain, however, being passed, gravelly slopes proceed from between stations 6 and 7; and by edging along the foot of the crest, above stations 7 and 8, and bending to the north, this valley may be reached several miles above station A, where the increased altitude and the natural declivity of the prairie would enable the engineer to locate a track for a road with a grade not much exceeding 100 feet per mile. The distance thence, by the course of the valley, to Camp 42, at Soda lake, is about 45 miles, with a descent of 2,618 feet, averaging nearly 60 feet per mile. The first portion of this distance, however, would be steeper than that near the lake, and the maximum would be from 90 to 100 feet per mile.

From the crossing of Sand-hill valley the trail led over an ascending prairie to Marl Springs. These issue from the foot of a granitic ridge, furnishing a small quantity of water at the surface. There is grass upon the hill-sides and at a few spots upon the plains, but the region is generally characterized by barrenness. Yucca trees and chamisa shrubs relieve its nakedness. From the springs a valley several miles in width leads in a southerly course to Sand-hill valley. Westward of Marl Springs there are high broken prairies, over which the trail passed. These are rocky and nearly destitute of vegetation. Upon the north of station 8 there is a large black mountain, beyond which appears a broad valley, parallel to the trail until opposite station 10. Beyond this station the trail turns toward the southwest, and descends a steep ravine to Camp 141, which is in a dry gorge between two mountains, where grass was found upon the slopes.

For three miles from Camp 141 the trail descends a gradually sloping prairie, with a declivity of about 200 feet per mile, to the border of a broad basin of white sand. This is a perfect desert, extending six miles to station 2. The surface is generally hard enough to bear the weight of horses. Opposite station D, upon the left, is a ridge of hills, with drifted sand piled upon the northwestern sides. Upon the right, seven miles distant, appears a high mountain range. Between stations 1 and 2 is a rocky ridge upon the north, with bluff sides from 200 to 300 feet in height. Beyond, the hills recede, leaving a wide vista north and south, apparently level for a great distance. At station 2 there are a few small sand-hills which lie upon the border of a dry lake, its surface indurated with ferruginous exhalations, or encrusted with white efflorescent salt. It extends toward the north, and is about four miles and a half in width between station 2 and Camp 142.

Camp 142 is upon the western border of the lake, 1,000 feet above the level of the sea. An abundance of rank, coarse grass grows in the vicinity, and large pools of brackish water were obtained by turning aside the marshy sod. Upon the north-northwest, about one mile and a half distant, there is a range of hills, upon the eastern slopes of which were Indian camp fires, and hence, probably, springs of water. Six miles south of camp there is another range of hills, and at a greater distance a high mountain is visible above it.

Leaving Soda lake we again entered a field of sand. It was loose, yielding to the pressure of feet, and occasionally drifted into hillocks. Upon the north and south, many miles distant, are ranges of high hills, seeming to enclose this desert space, which extends westward from Soda lake to Camp 143, twelve miles, with a uniform acclivity of 18 feet per mile. Here we first meet the flowing waters of Mojave river. At Camp 143 it is a clear and rapid rivulet. A short distance below, upon the north of the trail, it is lost in a bed of sand.

We now ascend the banks of Mojave river and enter a cañon, formed by the near approach of two ranges of hills about 300 feet in height. Near station 1 the cañon is contracted to 200 yards in width. At another narrow point, between stations 2 and 3, it is 300 yards wide.

Above, to Camp 144, the valley opens, the hills assume the character of a broken mesa formation, and the bottom-lands vary from a few hundred feet to nearly a mile in width. Wherever the stream appears flowing upon the surface, its banks are clothed with luxuriant vegetation, consisting principally of mezquite thickets, willows, and rank grass. Between stations 4 and 6 the water sinks, and the valley is sandy and barren. There is grama grass upon some of the hill slopes and in the ravines.

At Camp 144 there is running water, with grass and mezquite trees upon the banks. The width of the alluvial bottoms is 700 yards. Ascending the valley, we find it bounded by low grassy mesas from 25 to 80 feet above the stream. At station 1 the surface is dry and sandy. Station 2 is on a spur of the table-land which impinges upon the right bank of the stream. From station 2 to station 3 the trail crosses the river, ascends a prairie covered with luxuriant grass, and descends to the valley again at station 4. From this point to Camp 145, three miles and a half, the mesas recede, leaving a basin of arable soil several miles in width. A pretty stream flows through it, bordered with cotton-wood and tornillas, and the surface is covered with an exuberant growth of meadow grass. From this place the trail leads along the edge of a broad mesa; and at station 1, five miles from Camp 145, it enters the valley of Mojave river, at its intersection with the Mormon road from Great Salt Lake. The slopes are broad, and the valley, in many places, dry and sandy, until we reach station 5. From that point to Camp 146, the bottom-lands enclosed by hills become narrow. The stream bears a larger flow of water, and the banks are fertile.

Above Camp 146 the valley is from one to two miles in width, containing good soil and large groves of cotton-wood trees. The river is a continuously flowing stream, containing water sufficient to irrigate the wide bottom-lands below. At station 5 the trail turns from the valley to cut off a large bend of the river towards the northwest; and opposite station 6 is a break in the mesa, indicating the entrance of a ravine, or an arroyo, from the east. This is the point where it is proposed to leave the Mojave river, and proceed, by the route examined by Lieutenant Williamson, to Tah-ee-chay-pah Pass, and thence to San Francisco. For full descriptions of the surveys upon that line, reference will be made to Lieutenant Williamson's report, from which may be obtained a knowledge of the character of the country from the Mojave river across the Great Basin, and through the Tah-ee-chay-pah Pass into Tulare valley. The height of the Mojave river at the point between Camps 146 and 147, where we propose to leave it, is 2,313 feet above the sea. The latitude of this place is 34° 53′.5. Mr. Williamson's Dry lake is nearly west, about thirty miles distant, at an altitude of 2,388 feet above the sea, or seventy-five feet above the Majove river. The country between is an undulating prairie, deemed favorable for the location of a railroad. The width of the lake appears to be about 9.5 miles. From the western edge of it to the stream at the entrance to Tah-ee-chay-pah Pass, which has an elevation of 3,300 feet above the sea, the distance would be 23.5 miles, in a course slightly north of west, with an average grade of about 39 feet per mile. Thence ascending the stream 16½ miles to the summit of the pass, the maximum natural grade is 88 feet per mile.

The following extract from Captain Humphries's report will suffice to give an idea of the remainder of this route to the Pacific:

"The most direct route to San Francisco from the Tah-ee-chay-pah Pass will be found through one of the passes known to exist in the mountain range separating the San Joaquin valley from those of the Salinas river and San José river. The distance through them is about ten miles; the elevation of their summits about 600 feet. They may be reached from the Tah-ee-chay-pah Pass by passing around the head of the Tulares valley to its western side, or by keeping on the eastern side of the Tulares valley 15 or 20 miles after crossing Kern river, then crossing the valley; in doing which, it will be necessary to use piling for the distance of ten miles to make a sufficiently firm road-bed over the soft, miry, alluvial soil. The distance to the port of San Francisco, by this route, from the Tah-ee-chay-pah Pass, is about 288 miles. The average grades, except through the short pass, will be two or three feet per mile.

"The soil of the Tulares and San Joaquin valleys is well constituted for fertility, and needs merely the proper amount of water to be highly productive. There are settlements along the eastern side of these valleys under the mountains. The San José valley is one of the best cultivated and most populous districts of California.

"Sufficient water and fuel for working parties can be found at convenient distances on this section, and lumber and good building stone at various points along the line in the mountains, 15 or 20 miles from the foot of their western slopes."

Subsequent to the examinations previously referred to, a reconnoissance has been made in California by Lieutenant Parke, of the topographical engineers, and it is understood that he has found a highly favorable route, leading from Tah-ee-chay-pah Pass across the Coast Range to a branch of the Salinas river, and thence directly to San Francisco. His report will, probably, give specific information upon this subject.

It would be desirable to construct a branch railroad from the Mojave river to the port of Los Angeles. The country is well adapted to the purpose, excepting the portion embraced by the Cajon Pass. There, a long tunnel would be required through the crest of the summit, and grades from 100 to 150 feet per mile along the ravine in which the Cajon creek flows, or expensive cutting and filling across spurs of the mountain slopes. For a road of secondary importance, however, it might be deemed advisable to adopt the surface grades along the creek, and, perhaps, use stationary power to ascend the summit from the Pacific side. Upon those conditions the expense for constructing the road would be brought within very moderate limits.

GENERAL REMARKS UPON SPECIAL SUBJECTS.

TIMBER AND FUEL.

These necessary requisites for a railroad are found in great abundance upon several portions of our route. The State of Arkansas and the Choctaw Territory, as far as Shawneetown, abound in superb forests, and contain extensive beds of coal. Westward from Shawneetown, we have live-oak and black-jack in the Cross Timbers, and, in the valleys of the streams, as far as to the head-waters of the Washita, there is a growth of larger timber. Thence to the Pecos but few well wooded valleys occur, and the prairies which bound them are generally destitute of trees. Valley river and Shady creek contain groves of timber, and the Canadian is generally bordered by cotton-wood trees. Upon the slopes along the base of the Llano bluffs, near the head-waters of Tucumcari creek, and thence westwardly to Hurrah creek, there are extensive tracts covered with cedars affording a large supply of fuel. As we approach Anton Chico, cedars again appear, and upon the mountains, a short distance north, there are pine trees, such as are used throughout New Mexico for lumber. Between Rio Pecos and Rio Grande we pass through forests which afford, at convenient distances, both timber and fuel. A vein of coal crops out in the San Antonio cañon, but it is doubtful whether it can be obtained there in sufficient quantities to enable us to depend upon it for a supply of fuel. The Douglass' spruce and other firs, which cover the slopes of the Zandia mountains, would suffice for the requirements at this place.

Wood is scarce in the valley of Rio Grande. Fuel for the inhabitants is usually obtained from the Rio Puerco, where cedar thickets again appear. Near the latter stream good coal has been found, and there are indications of it further west, but the specimens obtained are said to be of inferior quality. The geologist supposes that the quantity which exists there is small.

Forests of stately pines cover the slopes of the Sierra Madre, furnishing an unfailing supply of timber and fuel.

Beyond Zuñi, a region of country, some thirty or forty miles in extent, is covered with a thick growth of cedars. Thence, fuel is scarce, for nearly an equal space, to Flax river. That stream rises in the well-wooded region of the Mogoyon mountains; and, by rafts during spring freshets, a supply of timber and fuel might doubtless be obtained. The banks of the river are skirted with cotton-wood trees. Leaving the valley, we immediately enter among small cedars, which increase in size and numbers, until reaching the base of the San Francisco mountains, they intermingle with, and finally give place to, immense forests of stately pines and Douglass' spruce. No finer timber grows in the interior of our continent. For 130 miles there is a constant succession of these forests. They disappear upon the head-waters of Williams' river. In the valley of that stream, as well as upon Rio Colorado, there are trees of cotton-wood and mezquite, which frequently form large and beautiful groves. They might prove useful in affording material for a primary supply of railroad ties. Among the ravines are a few cedars. Leaving Rio Colorado, we traverse a region for 110 miles almost destitute of fuel. Thence, the valley of Mojave river, sparsely fringed with mezquites and small cotton-woods, leads to the well-wooded region of the California mountains. By the direct route from the bend of the Mojave river across the basin to Tah-ee-chay-pah Pass, there is a space of above sixty-three miles of prairie, which would receive its supply of fuel and timber from the nearest points of the Sierra Nevada.

WATER.

The valley of the Canadian river is believed to contain springs and streams sufficient for railroad uses; common wells only at certain points being necessary to secure a permanent supply of water. From the head of Pajarito creek to Rio Pecos, springs and rivulets occur at convenient distances. From Rio Pecos to Rio Grande, artificial means would be required to preserve a perpetual supply of water in Cañon Blanco, and possibly at the Laguna. This object could be accomplished by an artesian well, or by a large tank at Camp 55, and an artificial reservoir at the Laguna. Thence to Isleta, the water stations that could be placed upon Rio San Antonio would probably be sufficient.

From Rio Grande to Rio Pecos, a distance of about 23 miles, the route crosses a waterless mesa. The latter stream contains running water for a portion of the year, and then sinks below the surface. A reservoir, or artesian well, would be required in its vicinity. Thence, up the valley of Rio San José to Campbell's Pass, in the Sierra Madre, there is sufficient water at moderate distances. From the fine spring of Agua Azul to Carrizo—a laguna which forms one of the head branches of Rio Puerco of the west—the distance is 25 miles. Thence, 10 miles lead to Ojo del Oso, another tributary of the same stream, which waters a fertile basin in the pass; and at the same distance beyond is found Salt Spring with brackish water. These springs flow down the Rio Puerco of the west, which is dry for a part of the year. It would be necessary to construct tanks in its valley, or common wells, to obtain a permanent supply of water at proper points. Near the lower portion of it, there are springs and tributary rivulets. Flax river is a permanent stream. Leaving it at Camp 82, we then find water at Cañon Diablo, Cosnino Caves, San Francisco Springs, and Leroux's Spring, the greatest distance between being about 20 miles. Other permanent springs can probably be found at intermediate points. From Leroux's Spring to New Year's Spring, the distance is about 23 miles. To obtain water between, tanks would be required. The route further south, previously suggested for examination, down the valley of Rio Verde, and across branches to Val de China, would doubtless prove better in every respect, and afford abundance of water. Partridge creek contains large pools of water, and is probably never dry. Pueblo creek is a flowing stream, from springs at its source in Aztec Pass. From near the same point commences a branch of Williams' river, which flows to the Colorado. No difficulty would be found in obtaining sufficient water at suitable points along its valley. The route now proposed, however, leaves that stream, and descends a branch called White Cliff creek, which also contains running water, to its junction with Big Sandy. Leaving the valley at Camp 111 to the left, and passing westward, the line crosses wide sloping prairies for 80 miles to the Colorado, near the Mojave villages. The Indians told us of two or three springs upon the way, and it is possible that water could be otained at other points, upon the mountain slopes, by artesian wells. A sufficient supply of water could undoubtedly be obtained by the construction of tanks. Ten miles west of the Colorado are the Little Springs. Painte creek is 21 miles beyond. Thence to Rock Spring is 20 miles; and Marl Spring is 20 miles beyond. The greatest jornada encountered is from Marl Springs to Soda lake, a distance of about 30 miles. It could, doubtless, be much diminished, by digging a well of moderate depth upon the eastern border of the lake. Many of the springs referred to are believed to be permanent. Several points of the crest of this mountain chain are above 5,000 feet in height, and it is evident that considerable precipitation of moisture takes place upon them. By the construction of reservoirs, sufficient water might be obtained for railway purposes. From Soda lake, it is a distance of 12 miles to the point where we found the flowing water of Mojave river. This stream now furnishes an abundance of water, until we reach its northwest bend, where the line leaves it to join the survey of Lieutenant Williamson, passing across the basin, through Tah-ee-chay-pah Pass, and to San Francisco. From Mr. Williamson's examinations, it seems probable that springs may be found at several points within the basin. It is the opinion of Mr.

Blake, the geologist, that, within this region, artesian borings may be resorted to with success. Within Tah-ee-chay-pah Pass there is water, and the remainder of the route to San Francisco is reported favorable in this respect.

SNOW.

Upon the parallel of 35° snow cannot prove an obstruction to a railway. From Memphis to Rio Pecos, snow-storms rarely occur. At Fort Smith, as has been shown, but one was noted in the winter of 1852, and that covered the ground to the depth of only two inches. From thence to the Pecos, three or four inches may occasionally fall, but must rapidly be absorbed by the warm porous soil. It is not likely that the surface would remain whitened for many days during the year. Passing the ranges of the Rocky mountains east, and the Sierra Madre west, of the Rio Grande, storms are said to be more frequent, snow sometimes covering the ground to the depth of one or two feet; but here, too, it quickly melts, and forms no obstruction to travellers. The latter range, which we passed late in November, was entirely bare. The first snow seen was in December, glistening upon the distant peaks of Sierra Mogoyon. During the latter part of December and the first of January we were at the base of the San Francisco mountains, where more was found than upon any other portion of the route. It scarcely ever exceeded eight inches in depth, was nowhere drifted, and formed little obstruction to our march. We learned, nevertheless, that the season was unusually severe, and the amount of snow greater than had been seen at that place during several previous winters. On the 18th of January, when upon a reconnaissance in the Aztec range, there was a fall of snow several inches in depth. Four days after, we were again at the same spot, and it had nearly disappeared—from the southern slopes entirely. Leaving this range, we saw no more indications of snow, except near a few mountain summits. Without doubt, between Aztec Pass and California, it may sometimes fall to the depth of half a foot, but in so mild a climate it soon melts away. At Tah-ee-chay-pah Pass, for a limited season, there may be a greater abundance of snow; but probably not enough to make a serious inconvenience to the use of a railroad passing through it.

CLIMATE.

One of the most important of the advantages claimed for this route is the pleasant and salubrious climate of the region through which it passes. There is no long series of parched plains, rendering the summer heat intolerable, nor do those dreaded winds termed "northers" reach this latitude. The mountain ranges that are crossed are not blocked up in winter by ice and snow sufficient to interrupt travel. From July to January, and for the whole year, this line may be traversed in safety.

The different portions of our survey were performed at such seasons as to enable us to make observations upon the most unfavorable characteristics of the climate. In August we were upon the comparatively low and arid plains upon the head-waters of the Canadian, and near the Llano Estacado. During the winter months we passed over the elevated region and through the mountain passes between Rio Grande and Rio Colorado. These observations may be found in Appendix H. They will be briefly alluded to in this place, although worthy of careful examination.

Judging from the material gathered upon the survey, the climate of the valley of Rio Grande is remarkably mild. One hundred and sixty-nine thermometric observations, taken there during the month of October, give 62°.2 for the mean temperature of that month. The highest temperature recorded is 100°.6; the lowest 25°.

In November we passed from Rio Grande to Zuñi, crossing the Sierra Madre. The mean temperature for that month is 52°.5; the maximum 82°.4, the minimum 23°.

During the month of December we were between Zuñi and the pass of the San Francisco

mountains; and, from one hundred and fifty-five observations, had a mean temperature of 41°.4, with a maximum of 73°.3, and a minimum of 15°.*

Upon the first of January we were at the highest point of our route, and during the month travelled to White Cliff creek. One hundred and twenty-six observations give for the mean temperature of January, in this region, 40°; the maximum being 73°.9, and the minimum 21°.

During the month of February observations were taken between White Cliff creek and the Mojave villages, in the valley of Rio Colorado. The mean temperature, from one hundred and seven observations, is 57°.4; the maximum is 80°, and the minimum 31°.

Although, as may be perceived, a few of the early morning observations indicated a considerable degree of cold, the sun was always warm, creating a visible effect upon the snow whenever it appeared.

In relation to this subject, I would refer to the hygrometrical tables of Appendix H, and also to the accompanying climatological map, with remarks prepared by L. Blodget, esq., from observations collected by the Smithsonian Institute, in connexion with those made during the survey. It will be perceived that the parallel of 35° is particularly favored by rain. The valley of the Canadian, the Zuñi region, the vicinity of the San Francisco mountains, and the Aquarius range have evidently a large supply of precipitated moisture. The arid regions between the Mississippi and the Pacific are here contracted to their narrowest limit.

Rough estimate of the amount of woodland,† prairie, arable soil, &c., upon the belt of country 15 *miles in width upon each side of the line from Fort Smith to Rio Mojave.*

Section.	Distance in miles.	No. of sq. miles in belt 30 miles wide.	Character.
From Fort Smith to Shawneetown	125	3,750	Woodland, $\frac{4}{5}$ = 3,000 sq. miles. Cultivable soil, $\frac{6}{10}$ = 2,250 do. Prairie and pasture land, $\frac{1}{4}$ = 937 do. Rocky hills, $\frac{1}{10}$ = 375 do.
From Shawneetown to head of Washita river.	185	5,550	Woodland, $\frac{2}{5}$ = 2,220 do. Cultivable soil, $\frac{2}{5}$ = 2,220 do. Rocky hills, $\frac{1}{40}$ = 138 do. Barren, $\frac{1}{40}$ = 138 do. Prairie and pasture land, $\frac{22}{40}$ = 3,052 do.
From head of Washita river to mouth of Tucumcari creek.	210	6,300	Woodland, $\frac{1}{90}$ = 70 do. Cultivable soil, $\frac{1}{15}$ = 420 do. Rocky hills, $\frac{1}{30}$ = 210 do. Barren, $\frac{1}{30}$ = 210 do. Prairie and pasture land, $\frac{83}{90}$ = 5,460 do.
From mouth of Tucumcari to head of Pajarito creek.	70	2,100	Woodland, $\frac{1}{5}$ = 420 do. Cultivable soil, $\frac{1}{5}$ = 420 do. Rocky hills, $\frac{1}{10}$ = 210 do. Prairie and pasture land, $\frac{7}{10}$ = 1,470 do.
From head of Pajarito creek to Anton Chico.	35	1,050	Woodland, $\frac{1}{10}$ = 105 do. Cultivable soil, $\frac{1}{30}$ = 35 do. Rocky hills, $\frac{1}{5}$ = 210 do. Prairie and pasture land, $\frac{7}{10}$ = 735 do.

* Upon one of the reconnoissances a lower temperature was noted. I have not the observations before me, but I think near the San Francisco mountains the thermometer read as low as 8° Fahrenheit.

† In the term "woodland" are included all those portions of the country covered with trees useful for timber or fuel. "Prairie and pasture land" refers to plains, and slopes, and valleys, which are generally covered with grass.

ROUGH ESTIMATE—Continued.

Section.	Distance in miles.	No. of sq. miles in belt 30 miles wide.	Character.
From Anton Chico to Rio Grande	85	2,550	Woodland, $\frac{1}{5}$ = 510 sq. miles. Cultivable soil, $\frac{1}{15}$ = 170 do. Rocky hills, $\frac{1}{5}$ = 510 do. Prairie and pasture land, $\frac{3}{5}$ = 1,530 do.
From Rio Grande to Campbell's Pass of the Sierra Madre.	95	2,850	Woodland, $\frac{1}{10}$ = 285 do. Cultivable soil, $\frac{1}{15}$ = 190 do. Rocky hills, $\frac{1}{10}$ = 285 do. Prairie and pasture, $\frac{8}{10}$ = 2,280 do.
From Campbell's Pass to Flax river	110	3,300	Woodland, $\frac{1}{10}$ = 330 do. Cultivable soil, $\frac{1}{30}$ = 110 do. Rocky hills, $\frac{1}{10}$ = 330 do. Prairie and pasture, $\frac{8}{10}$ = 2,640 do.
From Flax river to San Francisco Pass	100	3,000	Woodland, $\frac{1}{5}$ = 600 do. Cultivable soil, $\frac{1}{15}$ = 200 do. Rocky hills, $\frac{1}{10}$ = 300 do. Prairie and pasture land, $\frac{7}{10}$ = 2,100 do.
From San Francisco Pass to Aztec Pass	73	2,190	Woodland, $\frac{2}{5}$ = 876 do. Cultivable soil, $\frac{1}{10}$ = 219 do. Rocky hills, $\frac{1}{20}$ = 109 do. Prairie and pasture land, $\frac{11}{20}$ = 1,204 do.
From Aztec Pass to mouth of White Cliff creek.	42	1,260	Woodland, $\frac{1}{15}$ = 84 do. Cultivable soil, $\frac{1}{15}$ = 84 do. Rocky hills, $\frac{1}{15}$ = 84 do. Prairie and pasture land, $\frac{13}{15}$ = 1,092 do.
From mouth of White Cliff creek to Rio Colorado.	60	1,800	Woodland, $\frac{1}{100}$ = 18 do. Cultivable soil, $\frac{1}{12}$ = 150 do. Rocky hills, $\frac{1}{20}$ = 90 do. Prairie and pasture land, $\frac{94}{100}$ = 1,692 do.
From Rio Colorado to Soda lake	84	2,520	Woodland, $\frac{2}{500}$ = 10 do. Cultivable soil, $\frac{2}{500}$ = 10 do. Rocky hills, $\frac{1}{50}$ = 50 do. Sandy desert, $\frac{1}{20}$ = 126 do. Prairie and pasture land, $\frac{467}{500}$ = 2,335 do.
From Soda lake to northwest bend of Rio Mojave.	61	1,830	Woodland, $\frac{2}{500}$ = 7 do. Cultivable soil, $\frac{1}{30}$ = 61 do. Rocky hills, $\frac{1}{50}$ = 36 do. Sandy desert, $\frac{1}{30}$ = 61 do. Prairie and pasture land, $\frac{477}{500}$ = 1,726 do.

MINERALOGICAL RESOURCES.

For full and specific information upon this subject, I beg leave to refer to the geological reports. The following brief remarks are intended to convey a few general ideas regarding the value of the mineralogical outcrops of the country in relation to the construction and support of a railway. Many of the details here submitted were compiled from the Resumé of Mr. Marcou, geologist and mining engineer to the expedition. In some cases its concise language has been retained. Generally, the remarks have been condensed, and facts derived from other sources have been added.

The alluvium of the great valley of the Mississippi extends along the banks of the river Arkansas as far west as Little Rock. This place is situated upon a slaty hill, at the commencement of a metamorphic ridge of mountains. Upon the river's banks, a short distance above

the city, are found sandstones and limestones of the carboniferous period. "Here begins the fine coal-basin of Arkansas which" * * * "our survey traversed from the vicinity of Little Rock to Delaware Mount, a distance of several hundred miles; coal being found almost everywhere from Petit Jean mountain to Coal creek and the Shawnee mountains. It forms a vast reservoir for the sustenance of industry and commerce along the whole line of the Pacific railroad. This carboniferous basin contains, in addition to the coal, an abundance of excellent sandstone for building bridges and embankments, good beds of limestone for the manufacture of lime, and also iron. Artesian wells will give an immense supply of water for agricultural and other uses, and it may be predicted that this region will be one of the richest portions in the southern States of the Union."

From the Shawnee village to Little river there is excellent sandstone. Delaware Mount is formed of upheaved beds of carboniferous limestone, affording building material and quick-lime. After passing this ridge, we leave the carboniferous group and enter upon the new red sandstone or trias. This formation is four or five thousand feet in thickness, and its various strata are traversed upon our route westward, except among the mountains where we rise above it, for more than one thousand miles. Mr. Marcou establishes, provisionally, "three principal divisions in these rocks." The lower group is composed of red and blue clay at the base, and red sandstone above. It is some two or three thousand feet in thickness, and forms the surface of the country from Topofki creek to Rock Mary. In consequence of the prevalence of clayey soil, nearly the whole of this region is well watered by numerous rivulets, producing a bountiful fertility of forest and meadow. The sandstone upon this section is frequently coarse and friable. Quarries of good building stone may occasionally be found, though it is probable that bricks formed of the argillaceous clays would afford an economical and more durable material for masonry.

"The second group, or middle division" of the trias, "is formed of beds of red clay, containing very often immense masses of white gypsum, amorphous, furrowed with veins of crystallized gypsum, with interposition of strata of magnesian or dolomitic limestone, and frequently beds of rock-salt or saliferous clay are found superposed upon the gypsum. The height of the beds in this middle group is about fifteen hundred feet. We met with it on our route from Rock Mary to the Arroyo Bonito or Shady creek, with the exception of two points, where the direction taken by our expedition, near Camp No. 31, crossed strata of neocomien, and at Antelope Hills whitish-gray sandstone, which belongs to the upper division of the trias." The mineralogical characteristics of the group are of considerable importance. The sandstones upon this section occasionally exist in isolated masses, and appear like lofty colonades of some ruined city, and in many places have sufficient hardness and durability for embankments and bridges; the dolomite produces an excellent hydraulic lime; the gypsum exists in vast quantities, and may become valuable for exportation, and the salt will be useful for the inhabitants of this region. With the exception of the well-watered and wooded valleys leading to the Washita, the soil of this region is deficient in clay. Hence, the numerous arroyos leading to the Canadian, and the Canadian valley itself, are sandy; and many of the little rivulets, started into existence by occasional heavy rains, soon become dry from the percolation of the water to the substrata of clay some feet below the surface. By common wells this reservoir of water could easily be reached, and made available for the purposes of a railroad, or for settlements. Nature has planted upon the sandy borders of the streams of this region the plum and the grape. The soil seems admirably adapted to their growth.

"The third division, or upper group" of the trias, "is subdivided again into two parts. The lower is formed of thick beds of whitish-gray sandstone, often rose-colored, and even red; and the upper consists of beds of sandy calcareous clay of very brilliant colors—violet, red, yellow, and white—in a word, of variegated marls," like "the *marnes irisées* of France, or the variegated marls of England." "These rocks having very little consistency, have been carried away almost everywhere by denudations. It is only where they are capped by the jurassic strata that

they can be observed. The sandstone of this third division is very much developed, with rather an indistinct and very massive stratification. Its thickness is one thousand feet, while the variegated marls are only four or five hundred feet thick; making a whole of fifteen hundred feet for the upper group of trias. Upon our route this sandstone forms the summits of the table-lands or mesas, which extend on each bank of the Canadian river from Antelope Hills to the Llano Estacado; then it forms the bottom of the valleys from Rocky Dell creek and the Plaza Larga to Anton Chico and the Cañon Blanco." The fertility of the great basin lying between the bluffs of the Llano Estacado and the Canadian, and extending nearly from Rocky Dell creek across Plaza Larga, and thence to the head of Pajarito and Cuerbito creeks, may be ascribed to the prevalence of a sandy calcareous clay, belonging to the ata of the variegated marls, and to the streamlets that issue from the base of the Llano bluffs. Other portions of this region, except upon the borders of rivulets or springs, are comparatively barren.

The Llano Estacado is composed principally of a more recent formation which, by Mr. Marcou, is called jurassic. The summit of the first steppe of it, which we crossed, consists of a compact white limestone, resting upon white sandstone. The former will furnish lime, the latter may be used for masonry. Near Tucumcari mount the mesas are capped by superior strata of the same formation, consisting of blue clay, yellowish sandstone, and, at the summit, a compact, white, silicious limestone. "This formation is not limited to the Llano, but it forms the summits of all the plateaux that are seen to the north, in the direction of the Canadian river, and between the Canadian and the Raton mountains, as well as the majority of the mesas which extend from the Rio Pecos to the foot of the Sierra de Sandia. Our survey has also met with it on the other side of the Rio Puerco, forming, with volcanic lava, almost the whole road between Covero and the Sierra Madre, and finally, between Inscription Rock and the Pueblo of Zuñi, where it again forms mesas, which extend in the direction of Fort Defiance and the Cañon de Chelly." Near several of the points above mentioned "there are beds of bituminous coal in the clay, but only three or four inches thick, so that probably they would not be rich enough to be successfully worked."

In the cañon of San Antonio "the trias is met with again." It is here "upheaved and dislocated, the strata dipping to the east," and in the descent of the creek "gypsum, dolomite, sandstone, and red clay," are successively exposed. Near Tijeras, upon both sides of the gorge that has been cut through the Rocky mountains, "black schistose clay is seen, belonging to the coal measures; then grayish-blue limestone," containing fossils characteristic of the mountain limestone or lower carboniferous. Mr. Marcou remarks that "the presence of the black slate between the mountain limestone and the red clay of the trias indicates the existence of beds of coal on several points of the Rocky mountains;" and the inhabitants of New Mexico, he says, pointed out to him "beds of bituminous coal belonging, without any doubt, to the rocks of the coal measures." Similar indications of coal are found at various points of the Zandia and Santa Fé mountains, and at the village of Pecos. Several intelligent citizens of the Territory state that coal has been discovered in considerable quantities near Rio Puerco and in the vicinity of Cibolleta, and the quality was such as to cause it to be used in blacksmiths' shops. Some very fine specimens sent to us by Captain Ewell, of the dragoons, have been noticed in a preceding portion of this report. There can be no doubt of its good quality, and it is believed to be sufficiently abundant to afford a limited supply of light and economical fuel for railway engines, or for the uses of the inhabitants.

The other mineralogical resources of this Territory have, perhaps, been sufficiently referred to in the Itinerary. When it is admitted that the mountains extending from the Sierra de Oro, near Tuerto, to the Sierra de los Organos, near Las Cruces, contain mines of gold and silver that have been successfully worked for centuries by rude and unskilful processes, no one can doubt that a railroad to the Atlantic would cause the mining resources of this region to be developed, and that the advantages afforded would be reciprocal. Placers and mines are known to cover regions extending from the mountains of Taos to El Paso; and, judging from the

character of the country, the specimens collected, the reports of early Spanish explorers, and from Mexican traditions, it seems probable that large amounts of treasure exist at Gran Quivira, among the San Francisco mountains, in the Aztec range, and upon Williams' river. The salineras or salt-pits upon the plains between Rio Pecos and the Del Norte will become another important source of mineral wealth to the settlers of New Mexico.

Leaving the coal-bearing strata that crop out upon the eastern slope of the Zandia range, we find the centre of the line of dislocation of the Rocky mountains, where exist the rich auriferous veins already referred to, composed of serpentine and granitic rocks, affording a good building material. We then enter the valley of the Rio Grande where the granite is covered by drift and alluvium. From the Del Norte to the volcanic peak of San Mateo there exist white, friable sandstones of the trias or jurassic formation. Some portions of the cliffs which bound the edges of the mesas have considerable hardness, and, by quarrying, a good material for embankments, bridges, and other constructions, could be obtained in the vicinity of the route. As we approach San Mateo, streams of disintegrating lava are frequently found in the valleys. "Near the culminating point of the Sierra Madre the trias is replaced by the carboniferous limestone; then for a distance of twelve miles the rocks are eruptive granite, gneiss, and mica schist. Beyond, on the western declivity of the Sierra, comes the carboniferous again, the beds of the trias, and finally the white and yellow sandstones of the jurassic, with streams of volcanic lava in the valleys. Inscription Rock, and the whole mesa that extends nearly to Zuñi, are formed of the jurassic rocks." The vertical faces of these cliffs are covered with ancient Indian or early Spanish inscriptions. From the dates of the latter, it appears that more than two centuries have elapsed since they were executed, and the crumbling of the rock from atmospheric influences has not caused them to be effaced. This fact affords a proof of the value of the jurassic sandstones for a building material. They may be easily cut into blocks of the required dimensions, and in this climate, where the exfoliation by frosts is exceedingly slight, it would prove a durable material for railroad constructions. In many localities upon the line, we have, as before stated, rocks of the primitive or metamorphic formations; but so much of the route is bordered by sandstones that the above record of their durability becomes highly important with regard to their fitness for railway purposes.

The triassic rocks extend from Zuñi to the volcanic peaks near the head-waters of Rio Verde; containing sandstone and red clay, with dolomite and gypsum. Thence across the Aztec range to White Cliff creek, the sedimentary and granitic rocks have in many places been covered by lava and basalt; but among the former, we find "magnesian limestone, the sandstone of the coal measures, and the carboniferous limestone." In the vicinity of Partridge creek, there are indications of coal. This region is believed to be rich in precious metals; but, being traversed by us in mid-winter, when a thin sheet of snow covered a great portion of the surface, our examinations with regard to this subject were imperfect.

Williams' river cuts through low mountain chains of eruptive or metamorphic rocks, in which Mr. Marcou found "several veins of argentiferous lead." The region more directly west, from White Cliff creek to the Mojave villages, is mostly covered with diluvial drift, forming a smooth surface, and plains of gentle inclination. Granitic rocks are exposed upon the mountain ranges that lie upon the north. West of the Colorado, the Paiute mountains are crossed, where sienitic granite is found alternating with sandstones and limestones. The little cañon on the Mojave river will probably afford good quarries of stone.

"In the Cajon Pass," were discovered "sienite, trap, and serpentine, exactly similar to those found between Rough and Ready, Grass Valley, and Nevada City, and which contain the veins of auriferous quartz." As specimens were obtained at Los Angeles "very rich in gold, coming from the Cajon Pass, it is more than probable that this point will one day be one of the richest places in California."

"In an economical point of view," continues Mr. Marcou, "the eruptive rocks, which form almost the whole country between Cactus Pass and the Cajon Pass, will furnish excellent mate-

rials for the construction of bridges, roads, and houses; there are also very beautiful marbles, red porphyry, and especially, I think, will be found there, mines rich in silver and gold."

Having reached the foot of the Pacific slope of the mountains, the route to Los Angeles and San Pedro passes over an alluvial soil. Quarries of stone may be obtained upon the mountain slopes, not far distant from the trail.

Between Los Angeles and San Diego—but near the latter place—there are veins of coal. They were first discovered, I believe, by Captain Warner, of the topographical engineers, while making examinations of this country, in 1848. When I visited the place in 1850, several veins were found upon the surface, from an inch to an inch and a half in thickness, which afforded specimens of coal believed to be moderately good. Shafts had been dug, but abandoned on account of the small quantity of mineral obtained. Lately, it has been stated* that "a bed of good coal, sufficiently thick for working purposes, has been opened. A shaft has also been run down, piercing several small strata from 16 to 20 inches thick." Bitumen also is found in considerable quantities upon the coast. Near Los Angeles, there are large pits of petroleum, which will doubtless prove to be of some value as an article of commerce.

THE PROFILE.

After it has been determined that the natural resources of a country are of such a character as to afford facilities for the construction of a railway; that an adequate portion of the adjacent territory is susceptible of cultivation, and suitable for settlement; that materials for construction can be procured within the requisite distances, and permanent supplies of fuel and water insured at necessary points,—there remains the question of grade: 1st, as regards practicability; and 2d, economy. An examination of the country with the usual reconnoitring instruments—ascertaining the positions and heights of various points at considerable distances from each other—will, generally, be sufficient to determine the former. For the latter would be required a careful and minute survey of the whole line. Hence, in order to form an idea of the comparative advantages of different routes, general profiles are insufficient. The stations where altitudes are taken being at long intervals apart, the differences of altitude of these stations may be small; and, supposing that they can be connected by a uniform grade, a route represented may appear favorable; yet the intermediate minor ascents and descents may be so numerous and difficult, and the amount of cutting and filling required so great, that, where the line is of great length, the cost of the construction of a railroad would exceed practicable limits. The general profile of another route may present greater ascents and descents, and heavier grades; while the surface of the ground between the barometric stations is smooth, and the slopes are continuous and uniform, so that the cost of grading would be vastly less in the latter case than in the former. To form, therefore, a satisfactory conclusion in regard to the advantages of any proposed line, there is required more detailed information in regard to its topography than can be gathered from a profile showing only the grand general slopes, and the aggregate of their ascents and descents.

The country to be explored was of such extent, and the time so limited, that the field operations were necessarily hurried, and devoid of that accuracy which would have been desirable. In order, however, to give to our operations as nearly as possible the character of a survey, very numerous and frequent observations were made to determine the elevations and depressions along the line, and two complete sets of field sketches taken: the one exhibiting the general features of the country, and the other the special topography in the vicinity of the route traversed. From these have been constructed a series of topographical maps, on a scale of $\frac{1}{60000}$, delineating in detail a considerable portion of the profile trace. As the value of these maps depends upon the correctness of the altitudes given, it will be necessary to allude more fully to the method by which they were obtained.

* See Railroad Record, page 274.

The altitude of each camp is determined from a series of observations with mercurial barometers. The profile of each day's march is deduced from single observations, made with mercurial or aneroid barometers, at points where decided changes of elevation or depression occurred. The aneroid, when in use, was compared with the mercurial at every third hour during the day; from which comparison its error was determined.

The formula for the reduction of the observations have been strictly applied in accordance with the established rules. These are believed to have produced satisfactory results, excepting upon certain points, which will be stated in the course of these remarks. The first relates to a constant difference between the normal condition of the atmosphere upon the sea-coast and in the interior of the continent, with regard to the force of vapor. By a reference to the psychrometric tables it will be perceived, that at Beaverstown, in the Choctaw country, where our hygrometric observations were commenced, the mean elastic force of the vapor contained in the atmosphere was, by measurement, 17.1 millimetres, equal to 0.674 of an inch. This force was undoubtedly exerted upon the barometer at that place, in addition to the weight of the atmospheric column of dry air. Upon the Rocky mountains, east, and Sierra Madre, west of the Rio Grande—at Camps 56 and 67—the force of vapor measured from three to three and a half millimetres; or, at a mean, 0.126 of an inch. Therefore, to obtain the true differences between the weights of the atmospheric columns at the points referred to, it would be necessary to correct each barometer reading by the force of vapor known to be exerted upon it. The effect of such a correction, applied to our barometric observations, would be to diminish the computed altitudes, upon the most elevated parts of our survey, by nearly 600 feet;* which would greatly improve

* Upon the acknowledged principle that the vapor of water follows the same law as gases—viz: that one acts as a vacuum to another—it seems evident that the tension of vapor in the atmosphere must be a force exerted in addition to the gaseous pressure; and as the barometer measures the sum of the two forces, if either be known, it should be deducted from the barometric pressure to obtain the other. A distinguished meteorologist has suggested that a portion of the atmospheric column may be removed laterally, and replaced by the vapor of water, which, being a lighter fluid, may tend to neutralize, by diminished weight, the effect of increased elastic force. For example: when there exist surface currents of wind, highly charged with moisture, the heavy stratum of dry air is then replaced by a moist and light one; and, consequently, although the elastic force of vapor may have increased, the diminished pressure of the atmosphere effects a compensation, and the barometer does not rise. An occurrence of this kind would, I believe, form an exception to the general rule. At all events, it could not be applicable to a case like that in question, where a comparison is made between places far distant from each other, at which the normal conditions of the atmosphere are essentially different. The more I have examined the subject, the stronger has become my conviction that the barometric pressure at each point should have been divested of the force of vapor, and the weight of dry air alone used in the determination of differences of altitudes. However, in deference to the high authority of doubts that have been expressed regarding its propriety, I have refrained from making those corrections which would have so greatly modified and improved the profile of our route.

The following extract from a report of Lieutenant Colonel Sabine, R. A., "on some points in the meteorology of Bombay," discovered by me as this paper was about to be submitted to the department, has a direct bearing upon the subject under consideration:

"In concluding this communication, I beg respectfully to submit to the consideration of the eminent meteorologists here present, that it is very important towards the progress of this science that the propriety (in such discussions as the present) of separating the effect of the two elastic forces which are considered to unite in forming the barometric pressure, be speedily admitted or disproved. The very remarkable fact recently brought to our notice by Sir James Ross, as one of the results of his memorable voyage, that the mean height of the barometer is full an inch less in the latitude of 75° S. than in the tropics, and that it diminishes progressively from the tropics to the high latitudes, presses the consideration of this point upon our notice; for it is either explained wholly or in greater part by the diminution of the vapor constituent in the higher latitudes, which diminution appears nearly to correspond throughout to the decrease of barometric pressure observed by Sir James Ross; or it is a fact unexplained, and I believe hitherto unattempted to be explained, on any other hypothesis, and of so startling a character as to call for immediate attention.

"If, by deducting the tension of the vapor from the barometric pressure, we do indeed obtain a true measure of the pressure of the gaseous portion of the atmosphere, the variations of the mean annual gaseous pressure, which will thus be obtained in different parts of the globe, and the differences of pressure in different seasons at individual stations, may be expected to throw a much clearer light than we have hitherto possessed on those great aerial currents which owe their origin to variations of temperature proceeding partly from the different angles of inclination at which the sun's rays are received, and partly from the nature and configuration of the material bodies at the surface of the earth; and a field of research appears to be thus opened, by which our knowledge of both the persistent and the periodical disturbances of the equilibrium of the atmosphere may be greatly extended."

the appearance of the profile of the line. In conformity, however, with the practice of meteorologists, this element of variable pressure has not been taken into account. All the data upon which it depends are submitted; and when scientific investigations, that are now in progress, have sufficiently tested the subject, the error due to the variations in tension of vapor may be determined, and the altitude of each station properly reduced.

The corrections applied to the original record of the barometric observations are as follows:

1st. For relative expansion of column of mercury and scale due to variations of heat, in order to reduce the observations to an equivalent, at a temperature of 32° Fahrenheit. For this purpose, Professor Guiot's excellent tables were used.

2d. For constant error of barometer, or the difference between the zero point of its scale and that of the standard with which it was compared. The errors of the various barometers used are shown in the Appendix.

3d. For oscillations of the barometric column, due to diurnal variations of atmospheric pressure, and determined by hourly observations, taken for several consecutive days, at various points upon the route. The results obtained for this correction are also shown in the appendix.

All barometric oscillations seem to be due primarily to variations of temperature. Let the atmosphere be placed in equilibrio, and everywhere, at equal elevations, the columns of mercury supported would be the same. But as soon as one portion of the ærial fluid is warmed by the sun it expands, rises, and overflows the regions contiguous, producing currents of air more or less violent. The heated column becomes lighter, and the colder heavier, in consequence of the superincumbent mass. The effect upon the barometer is, however, greatly modified by the vapor of water which is at the same time generated by heat, and by its elastic force tends to increase the pressure. By the daily revolution of the earth, consecutive portions of its atmosphere are warmed, causing horary oscillations, which amount to about 2.5 millimetres within the tropics, and become almost inappreciable as we approach the frigid zone. Two points of maximum and two of minimum pressure occur during the twenty-four hours,* and their periods are determined by the relative value of the influences produced by heat upon dry air and upon moisture.

4th. For abnormal changes of atmospheric pressure, sometimes termed barometric waves. Contact of the air with an extensive surface of land heated by the sun's rays, and currents of wind charged with a greater or less amount of moisture, create another system of atmospheric dilatations, the effects of which may, in some respects, be compared to tides upon the ocean. Within large areas they produce simultaneous oscillations of the barometric column, called *abnormal.*† They recur at irregular periods, and are variable in their character. Their magnitude is less within the tropics than in the temperate zones. Within the limits of our western

* The remarks submitted above were entirely suggested by the reduction of the observations made upon the Pacific railroad explorations, and were informally communicated to the department some time since. Lately, through the kindness of Professor Henry, the distinguished secretary of the Smithsonian Institution, I have received a copy of a lecture on meteorology, delivered before that institution by Robert Russell, Esq., with an appendix by the secretary, giving much information upon this subject. The whole pamphlet is highly interesting. With regard to the horary oscillations of the barometer, Professor Henry remarks as follows:

"The fact that the barometer exhibits two maxima and two minima in the course of twenty-four hours has given rise to much speculation as to its cause. The most common explanation is, that it is due to the joint action of the variation of the temperature and moisture. In the morning, the moisture rising into the atmosphere increases the weight of the air more than the heat diminishes it by expansion; while at about ten o'clock a. m. the effect of heat overbalances that of vapor, and again as the sun begins to decline the weight of the latter predominates. Mr. Espy attributes the daily oscillations of the barometer to the upward and downward motion of the particles of air and moisture as they are separated or approximated by the change of temperature. The particles weigh more while the rate of separation is increasing, and less while it is diminishing. This is a true cause, but we are not certain that it is a sufficient one. Whatever may be the cause of the daily oscillations of the barometer, we know the effect is nearly the same in parts of the earth most widely separated."

According to the analysis of Mr. Dove, (see Kaemtz's Meteorology,) the pressure of dry air, when freed from the tension of vapor, exhibited but one diurnal *maximum and minimum.* Instances have occurred where the readings of the barometer, uncorrected for the force of vapor, have given a similar result.

† Abnormal oscillations include the residual errors of the barometric results, when corrected for all the atmospheric changes that may be measured.

territory, the maximum amplitude of these tides, as measured by the barometer, is about one inch—corresponding to 1,000 feet of elevation; though in latitude 35° it is somewhat less. Hence the necessity for simultaneous observations at those points whose differences of altitude are to be determined by the barometer; or, what is equivalent to it, corresponding observations at some fixed station, within the same barometric region, in order to mark the period and measure the amplitude of the oscillations for the determination of the correction due to them.

The latter plan has been adopted in our reconnoissance. For its execution, we have been furnished by the Surgeon General's Department with unpublished records kept by officers of the medical corps at various military posts in the vicinity of our route, and use has been made also of corresponding observations upon Governor Stevens' and Captain Beckwith's lines of survey.

On account of the slight knowledge heretofore existing with regard to the climatological character of the region between the Mississippi valley and the Pacific ocean, it could not be determined, in advance, between what limits the ærial tides could be considered sufficiently coincident to render barometric observations, taken at different points, comparable. This question was elucidated by the construction of diagrams, which exhibit the curves of unequal pressure, observed upon our line, and the corresponding oscillations obtained from the various records previously referred to. The diagrams are appended to this report, and probably will be examined with considerable interest. In noticing some of the ideas which they have suggested, it is not proposed to enter into a general discussion of the problem of variable atmospheric pressure: the data before us are too meagre. Until governments, or individuals, interested in scientific researches, choose to unite in an extensive system of atmospheric observations, we must continue to be dependent upon theories, more or less vague and unsatisfactory. Were America and Europe to combine in the undertaking, it would not be difficult nor expensive to arrange and carry out a plan of operations, whereby light-houses upon the coasts, and military posts in the interior, might be provided with instruments and observers; and a comparison of the records thus obtained would lead to a solution of most of the laws of the so-called meteorological phenomena. This is one of the great desiderata of science at the present day. Our own government, by the co-operation of its officers of the army and navy, and by the voluntary contributions of its citizens at home and abroad, might well take the initiative in the determination of the causes of winds, clouds, and rain; of variations of heat and atmospheric pressure; and thus add to the sum of human knowledge that which would be of incalculable value to man in every branch of practical industry.

From a comparison of the observations appended to this report, it appears that in the Mississippi valley currents of moist heated air from the Gulf of Mexico create a disturbance of the atmosphere, and produce local storms. To what distance westward their effects are communicated to the barometer can scarcely be deduced from the limited data examined. Our observations, however, at Napoleon, June 24, 1853, and those taken simultaneously at Memphis, marked a period of great atmospheric pressure. This same phenomenon was noted at all the barometric stations of the Mississippi valley, and at Fort Gibson in the Creek territory.

The Llano Estacado and great western prairies, being heated by the sun's rays, rarify the superincumbent atmosphere, modifying the climate, and doubtless also the series of barometric waves of the Mississippi valley; yet, from the diagram it appears that all the oscillations noticed at Fort Gibson, between July and September, inclusive, were felt almost simultaneously upon our line from Fort Smith to New Mexico. In October, the curves of variable pressure at Albuquerque still correspond to those observed at Fort Gibson, except as regards some of the periods of maxima and minima; and in December, even as far westward as the Colorado Chiquito—Flax river—a striking similarity continues for a considerable period.

The few observations collected for the month of December illustrate one important fact—the widely-spread influence of a single barometric wave. Between the 4th and 10th, a remarkably uniform rise and fall of the barometer is indicated at Fort Benton, near the eastern base of the Rocky mountains; opposite, at St. Mary's, on the head-waters of Clark's Fork of the Colum-

bia; at Fort Gibson, on the Arkansas; at Great Salt Lake City; at camps upon the Colorado Chiquito; and, though in a less degree, at San Diego, California. Hence, it appears that the same tide of low atmospheric pressure covered at once a large portion of the western part of this continent. It would be of interest to compare other observations made at the same period, and determine whether, upon distant points of the globe, correspondingly high pressures were produced. The phenomena commenced at Fort Benton and St. Mary's one day earlier than at Great Salt Lake, and at other places further south. This fact is particularly noticeable in the secondary oscillation of the 11th and 12th.

The meteorological record at Great Salt Lake conforms closely with the observations at Flax river. At both places the weather continued "clear and pleasant" during the first rise and part of the gradual fall of the barometer. Clouds were then formed. On the 10th, light showers occurred. This disturbance of the atmosphere having restored the equilibrium of pressure, the mercury rose, although heavy masses of threatening clouds were still visible. On the 12th, the tide of pressure turned, and the mercury fell rapidly until the night of the 13th, when occurred a light snow-storm. From this period the barometer remained almost stationary for a day and a half, and then commenced a gradual and uniform rise, notwithstanding the continuance of a series of violent storms of wind, rain, sleet and snow that swept from the San Francisco mountains.

This comparison leads to the following opinions regarding the abnormal movements of the barometer:*

1st. They are of great magnitude, and, if not taken into account, may produce an error in the deduced altitude of several hundreds of feet.

2d. They are but slightly affected by local storms.

3d. They *may* occur almost simultaneously over the whole interior portion of the continent.

4th. They are actually identical within certain areas of great extent.

Our line, from the Mississippi valley to the Pacific, crosses three distinct barometric regions. The first covers the extensive prairies east of the Rocky mountains; the second lies within the great basin and the valley of Rio Colorado; and the last occurs upon the Pacific slope of the Sierra Nevada. These different countries may be equally affected by heat and vapor, and produce similar changes of the barometric column. Usually, however, their waves are non-conformable, except when they meet and mingle near the immediate ranges of mountains.

The idea of applying to our barometric observations a correction, to be obtained by the plan alluded to above, was first entertained in the field; otherwise, it would have been necessary to have divided our party into two barometric divisions—one to be stationary, while the other was *en route*—a system which would have considerably retarded the operations. But upon our return to Washington, while hastily preparing the material for a profile, I was informed that no records of observations could be obtained suitable for a comparison. Hence, under the direction of L. Blodget, esq., then meteorologist of the Smithsonian Institute, our notes were computed in the manner described by him in a preface to the tables. Afterward, when called upon to review the work, I found that, notwithstanding the careful manner in which the observations had been reduced, there might be errors, due to the abnormal atmospheric changes, remaining uncorrected.

In the effort to determine these errors, and whether some practical method might be found for eliminating them, the idea of making a diagram of the observations was suggested. Those

* From observations made, for ten days together, by F. Laval, upon the top of St. Pilen, a mountain near Marseilles, which is 960 yards high, [see Russell's lectures, previously alluded to,] John Dalton remarks that "it may be inferred that the fluctuations of the barometer are occasioned chiefly by a variation in the density of the lower regions of the air, and not by an alternate elevation and depression of the whole superincumbent atmosphere." This theory, if true, would diminish the value of the barometer as an instrument for determining altitudes. However, the barometric waves in the elevated regions of the Rocky mountains are not appreciably less than at Fort Gibson, with a difference in altitude of 5,000 feet. Hence, while the observations are confined to the stratum near the general surface of the earth, it seems to be evident that the amount of the barometric oscillations is independent of the height above the sea.

made upon our line were developed into a curve; the abscissæ representing the times of observation, and the ordinates, corresponding readings, or rather fluctuations, of the barometer; the measured difference between the altitudes of any two ordinates being the true elevation or depression of the mercurial column after all the known corrections had been applied. This curve was found to be remarkably regular, so long as the observations from which it was plotted were made at the same station. But upon a change of place, the base being altered, the continuity of the line was broken; and observations made at the second station could not be compared with those taken a few hours before at the first, until the barometric movement for the intermediate time should be made known. This could be satisfactorily determined only by observations upon a barometer at rest during that period. Upon inquiry, it was ascertained that, subsequent to our first computations, barometric records had been received at the Surgeon General's office from various military posts in the vicinity of our route. To decide which of them would serve to connect the broken links of our series between consecutive stations, similar developments were made upon the diagram of other records covering the same periods of time. A comparison of them all showed which corresponded most nearly with our own. If day after day the oscillations at some fixed station were identical with those shown by the records made by us in two or more camps, it is fair to assume that, during our progress between those camps, the atmospheric dilatations were correctly represented in the same series.

This principle being established, its application was easy. By a construction, more elaborate than has been attempted in the diagram, a complete curve of the variable pressure upon our whole route might be represented. Then, having drawn a horizontal line to denote the mean pressure, the abnormal error at any hour, during the required period, could be measured off above or below, and applied, with its proper sign, to the observation; but, for the reduction of our profile, a simpler plan was adopted. Having, by the diagram, decided with which of the fixed barometric stations it was desirable to compare, the observations at that place were examined, and tables of the dilatations were made out, to be used as corrections. In deducing these lists of corrections, I am greatly indebted to Dr. R. H. Coolidge, United States army, and to Lorin Blodget, esq., for extending every facility and assistance that the Surgeon General's department could afford.

For the determination of the profile of different portions of our line, corresponding observations were compared, as follows, viz:

From Fort Smith to Rio del Norte, with Fort Gibson. From Rio del Norte to Camp 73, (less satisfactorily,) with Fort Gibson. From Camp 73 to Camp 91, (Leroux's Spring,) with Great Salt Lake. From Leroux's Spring to Camp 113, on Williams' river, with Fort Yuma. From Camp 113 to Camp 134, (last on Rio Colorado,) with mean between Great Salt Lake and San Diego. From Camp 134 to the Pacific, with San Diego.

Beside the comparisons above mentioned, the relative heights of many of the principal points were obtained by simultaneous observations at different stations along our route. This was done whenever the party was divided for the purpose of making explorations in advance of the main survey; and the duplicate sets of observations then taken have proved valuable tests to the results.

The readings of the barometer being thus corrected for expansion, horary oscillations, and abnormal variations, the altitudes of the points of observation were deduced by the hypsometrical tables calculated by Professor Loomis after the formula of Laplace. These tables were convenient and highly satisfactory, except with reference to a single term of the corrections, viz: that relating to the air temperatures. For the want of corresponding observations, made at appropriate fixed stations, the mean height of the mercurial column and mean temperature at the sea level in latitude 35° were assumed as the bases for comparison. It is evident that the observations obtained at the various points upon the survey should also be reduced to mean values, in order to be comparable with the assumed data. With regard to the barometer, this was accomplished with some pretensions to accuracy. The air temperatures, however, in consequence of

an oversight, due to the hasty manner in which the reductions were made, were not brought to that standard; but, in the first computations, the corrections for that element were based upon the observed reading, without regard to the hour of observation. Mr. Blodget soon saw that the effect was to introduce an error into the results, and therefore he assumed a table of modifications, by which each of the high temperatures was reduced, and the low temperatures were increased, by a quantity depending upon the observed reading. This was a wise precaution, serving to diminish the inaccuracies that were introduced into the first results, and leaving but small residual errors. The necessity of reducing the temperatures to their mean determinations was not understood until too late to apply the rule to the computations. It is believed, however, that the errors resulting from this neglect will not be found of much magnitude, and they are probably all upon the safe side, viz: they have increased the elevations of those points where observations were made during the middle portion of the day; rendering the grades too abrupt and the profile too broken to represent the natural slope of the ground.

In concluding the remarks with regard to this subject, it may not be deemed improper to mention that our operations have excited a spirit of inquiry after facts, and an investigation of the laws that govern the fluctuations of the barometric column. Parties that have succeeded ours in the field have thus been enabled to profit by our experience, and obtain results which prove that the general method of determining differences of altitude by measurements of atmospheric pressure is susceptible of a closer degree of accuracy than its advocates have heretofore claimed. The importance of such a determination will be appreciated by those who reflect upon the vast expense and labor which would be required to obtain profiles of the interior portion of our territory by any other process. Excepting the small errors that have been referred to, this portion of our work is believed to possess a satisfactory degree of accuracy. Each camp having been referred directly to the sea-level, the minor discrepancies, which in such a reconnoissance cannot easily be avoided, have not been suffered to accumulate. The camps, therefore, may be considered as the standard points of reference for the profile line. The contour of the ground between them was determined by an independent system; aneroid or mercurial barometers having been observed at the most important stations upon each day's march, and topographical sketches made of the whole belt of country within the field of view. The data thus gathered forms material for a series of maps upon a scale of $\frac{1}{60000}$ with curved lines, fine and coarse, to represent the sections of horizontal planes, ten and fifty feet apart. Although founded upon rapid examinations—strict accuracy not being claimed for all of the details—a delineation upon this scale was necessary, in order to exhibit the character of the country in accordance with our field-notes. Upon the topography of these maps we may trace the line most favorable for a railroad, and measure the curves and grades which the contour would require. A profile of this route has also been made upon the same large scale, showing approximately the cutting and filling necessary to produce the grades which are given. This differs materially, both as regards length and elevation, from the one previously submitted to the department, the latter exhibiting merely the wagon trail with the altitudes uncorrected for abnormal error.

In order to avoid the great expense of publishing the detailed maps and profiles previously alluded to, the greater part of the results which they have enabled us to arrive at, relating to distances and grades, as well as excavation and embankment, is condensed; and the former is presented in the accompanying table, marked Appendix N. In that may be found one of the most serious objections to which this route is liable, viz: a long succession of heavy grades through the mountainous regions of the interior. Future examinations over sections already referred to in the preceding pages, or through passes not yet discovered, will undoubtedly enable the engineer to modify and greatly improve the location of the line. The steep declivity and expensive rock-cutting in the San Antonio cañon, may be rendered unnecessary by following the Galisteo river. The elevated and somewhat broken region, between San Francisco Springs and Aztec Pass, may probably be avoided by pursuing a more southerly course, as indicated by

the dotted line upon the map. Should it be desirable to terminate the road at San Diego or Los Angeles, it might be found preferable even to descend the Rio Verde and the Salinas to Rio Gila, and there unite with the southern route. Such a connexion would join, by a cultivable valley, the most favorable parts of the two routes; and present a line bordered with arable soil adapted for settlement throughout a great portion of the distance between the Mississippi and the Pacific.

Other lines, dotted upon the map, are respectfully recommended for examination. One is from Rio Gallinas, via Ojo de Vernal, to Rio Pecos at San Miguel; and thence across the mesa to a branch of Rio Galisteo, which leads to Rio del Norte, at San Felipe. Crossing the river at that point, the line keeps a south-southwesterly course, to ascend the bluffs which bound it, then enters the valley of Rio Puerco, and joins the line of survey in the valley of Rio San José. Another route is indicated from the Val de China, through a break in the Aztec range near Sierra Prieta, and thence down Rio Santa Maria and Williams' river to the Colorado. From the latter point a practicable route is believed to lead in nearly a direct course to Soda lake.

By some of the methods suggested, it is believed that the greater part of the steep grades shown upon the profile, and given in the table, may be avoided. The length of the line might thereby be somewhat increased, but the expense of construction would probably be diminished.

By a reference to the general maps it will be perceived that, in two instances, the trace for the profile departs widely from the positon of the wagon and reconnoitring trails. The first is from Big Sandy creek to the Colorado; the second, from the Sacramento Springs to Soda lake. The country, however, in those regions is so open, that the several parts of it were plainly visible from various points upon our trail; and the plotting of the triangulation notes, connected by the topographical sketches, left no doubt upon our minds that its character is such as is represented. By the former, the great bend of Williams' river is avoided, making the distance to the Mojave village considerably less, and producing also a saving in expense for rock-cutting and bridging. The grades, on the other hand, are greatly increased. The latter deflection effects a saving both in distance and in grade. Upon both, tanks would probably be required at some of the necessary watering stations.

With reference to the elevation of the interior portion of the continent, as determined by comparative barometric measurements, it has already been stated that, from the non-application of a correction believed to be due to the diminution of the force of vapor in that region, the altitudes upon the central part of our line are probably several hundred feet too great. In the consideration of this subject, another idea has been suggested, viz: that a column of air upon the seacoast, the weight of which is taken as the standard of comparison, may contain, not only a large amount of vapor of water, but salts and other impurities in suspension, such as the air of the interior of the continent would be free from. In consequence of such unequal conditions of the air, differences of altitude would be too great, when deduced from the measured weights of the atmospheric columns. The amount of error due to this cause is probably small, yet it seems to be a subject worthy of investigation. However we may regret to throw doubt upon the final accuracy of the profile, it is gratifying to believe that the errors it contains have constantly the effect of exaggerating the difficulties to be overcome, and that future examinations will lead to more favorable results.

In the table of grades, which has been carefully deduced from the field-notes of the survey, the maximum inclination is believed to have been noted upon every portion of the line, except from the point of leaving the Mojave river to Tah-ee-chay-pah Pass. There, but few points are given in altitude, and, between them, mean inclinations are represented. The intermediate elevations and depressions would increase the grades; but, from the general appearance of the country, I should have estimated the amount somewhat less than Lieutenant Williamson has stated in his report. In order to exhibit the proposed termination of this line upon the Pacific, by the consent of the department, the profile of Lieutenant Williamson is adopted from Tah-ee-chay-pah Pass to San Francisco.

The sum of ascents and descents upon the whole line amounts to 47,539 feet; which, with the full working power of the road developed, would be equivalent (according to the formula of Messrs. Latrobe and Knight) to 900 miles of level grade. With the amount of work, however, estimated for the Pacific railway, the equated length, corresponding to the sum of ascents and descents, is supposed to be of little practical value.

COST OF CONSTRUCTION.

The various explorations that have been made under orders from the War Department, make it sufficiently evident that the country between the Mississippi river and the Pacific ocean may be traversed by several lines, which are not so unfavorable for the location of a railway as heretofore supposed. The closer the subject is examined, the less serious appear the obstacles to be encountered, so far as they relate to the local conditions of the grade, curvature, and the characteristics of the soil; but the hasty manner in which the explorations were necessarily made, precludes the possibility of forming a satisfactory computation of the cost of constructing a railroad upon either of the lines. With the preliminary reports of the field-work before them, practical engineers differ widely in the conclusions to which they arrive upon this point. It is natural, perhaps, that one, desirous of impressing the public with a conviction of the practicability of the route which seems to him worthy to be adopted—particularly if guided, in a considerable degree, by conjecture rather than computation—should base his estimates upon the most favorable terms, and undervalue the difficulties incident to the country to be traversed. On the other hand, looking only at the magnitude of the undertaking, and anxious to convey a just appreciation of it, it would be equally easy to err upon the side of exaggeration. Besides, engineers differ in their ideas regarding the character of the road to be constructed: some estimating for a single track, with light rails, and a narrow gauge; others for a double track, and more expensive characteristics. Hence, when such varied estimates apply to different routes, a comparison of them affords no criterion for determining the relative merits of the lines proposed.

It would be a source of regret to me if, through any neglect or error of judgment upon my part, a false impression should be conveyed to the department upon this highly important question. To avoid it as far as practicable, the data upon which the following estimate is based will be submitted, that others, with practical experience in railroad engineering, in which I am deficient, may re-examine the details, and correct the errors which may be made.

The principal streams for the transportation of supplies, in the construction of a road, are the Arkansas and Canadian rivers upon the eastern division, and Rio Colorado and San Joaquin upon the western. The Colorado would doubtless be navigable to the Mojave village, for steamboats of light draught, for the greater portion of the year. The Canadian could be navigated in like manner, certainly, to Beaverstown, about 200 miles west from Fort Smith, and possibly, during the wet season, a considerable distance beyond. The main depots, therefore, for supplies, would be at Fort Smith and Beaverstown upon the east, and San Francisco and Mojave village on the west. For the distance within the two interior points—1,200 miles—it would be necessary to rely mainly upon land transportation.

For the preparation of the road-bed, parties might, with advantage, commence operations at each of the four points above mentioned, and proceed also east and west from Rio Grande. In distributing the iron, and laying the tracks, it would be economical to work from the main depots only, that the road itself may bear the chief burden of the land transportation. Progressing simultaneously from Beaverstown and Rio Colorado toward the interior, and laying tracks at an average of half a mile upon each side daily, it would require about three and a half years to effect a junction.

In the following estimate of the *cost of construction*, less expensive characteristics are assumed than those upon which the estimate in my preliminary report was based. The weight of rail is reduced to 75 pounds per yard. A single track, with sidings, is substituted for a double

track; and the full equipment is diminished to a proportion which is esteemed sufficient for the required service of the road. Another element of this reduction is founded upon the idea, that, the line having been decided upon, the country will be opened to settlers, who, occupying a great portion of the arable valleys upon the route, will be able to furnish much of the subsistence necessary for the laborers, and, in various ways, may aid in the construction of the road.

The various items of the estimate are, however, founded upon actual computation, as far as the details of the survey would admit; and where explicit data were wanting, all the known circumstances of the case have been weighed, and every doubtful point taken into consideration, in order that the amounts stated may not fall short of the necessary expense. Over the most difficult parts of the line, elaborated profiles, upon the horizontal scale of $\frac{1}{60000}$—the vertical being exaggerated 50 times—have given facilities for an approximate computation of the cutting and filling that would be required; and in the determination of the earthwork, masonry, &c., for a considerable portion of the work, I would acknowledge the valuable assistance received from Albert H. Campbell, esq., civil engineer.

ESTIMATE.

Section 1.—*From Fort Smith to the head of Pajarito creek,* 706 *miles.*

GRADUATION, MASONRY, ETC.

Earthwork, 13,012,124 cubic yards, at 15 cents	$1,951,819	
Rock-cutting, 305,793 cubic yards, at $1	305,793	
Masonry, 175,809 cubic yards, at $4	703,236	
Bridging, 4,960 feet, at $30	148,800	
Grubbing and clearing, 350 miles, at $200	70,000	
Ballasting, 350 miles, at $1,000	350,000	
	3,529,648	
Add 50 per cent. for increase over eastern prices	1,764,824	
Amount for graduation, masonry, &c		$5,294,472

SUPERSTRUCTURE.

Cross-ties for 706 miles, averaging $1,200 per mile	847,200	
Railroad iron—75 pounds per yard—delivered at Fort Smith, for single track and sidings for 706 miles, 102,511.2 tons, at $80 per ton	8,200,896	
Transportation of same 353 miles, at 3 cents per ton per mile	1,085,594	
Wrought iron chairs and spikes for 706 miles, at $500 per mile	353,000	
Distributing and placing iron and cross-ties, 706 miles, at $1,000 per mile	706,000	
Amount for superstructure		11,192,690

EQUIPMENT.

Locomotives, 80, at $10,000	800,000
Passenger cars, 70, at $3,000	210,000
Baggage cars, 25, at $1,500	37,500
Freight cars, 1,200, at $1,000	1,200,000

Engine-houses and passenger depots	$250,000	
Way stations for water and wood	250,000	
Amount for equipment		$2,747,500
For engineering and contingencies, add 10 per cent		1,923,466
Amount		21,158,128
Average cost per mile		29,969

Section 2.—From the head of Pajarito creek to Isleta, 144 miles.

GRADUATION, MASONRY, ETC.

Earthwork, 4,520,000 cubic yards, at 15 cents	678,000	
Rock-cutting, 2,880,000 cubic yards, at $1	2,880,000	
Masonry, 43,200 cubic yards, at $4	172,800	
Bridging, 5,660 feet, at $40	226,400	
Grubbing and clearing, 100 miles, at $200	20,000	
Ballasting, 20 miles, at $1,000	20,000	
	3,997,200	
Add 50 per cent. for increase over eastern prices	1,998,600	
Amount for graduation, masonry, &c.		5,995,800

SUPERSTRUCTURE.

Cross-ties for 144 miles, averaging $1,500 per mile	216,000	
Railroad iron—75 pounds per yard—delivered at Fort Smith, for single track and sidings for 144 miles, 20,908.8 tons, at $80 per ton	1,672,684	
Transportation of same 778 miles, at 4 cents per ton per mile	650,680	
Wrought iron chairs and spikes for 144 miles, at $600 per mile	86,400	
Distributing and placing iron and cross-ties, 144 miles, at $1,000 per mile	144,000	
Amount for superstructure		2,769,764

EQUIPMENT.

Locomotives, 16, at $10,000	160,000	
Passenger cars, 15, at 3,000	45,000	
Baggage cars, 4, at $1,500	6,000	
Freight cars, 245, at 1,000	245,000	
Engine-houses and passenger depots	100,000	
Way stations for water and wood	150,000	
Amount for equipment		706,000
		9,471,564
For engineering and contingencies, add 10 per cent		947,156
Amount		10,418,720
Average cost per mile		72,352

Section 3.—*From Isleta to Campbell's Pass*, 116.7 *miles.*

GRADUATION, MASONRY, ETC.

Earthwork, 2,015,000 cubic yards, at 15 cents	$302,250	
Rock-cutting, 215,000 cubic yards, at $1	215,000	
Masonry, 37,000 cubic yards, at $4	148,000	
Bridging, 1,800 feet, at $30	54,000	
Grubbing and clearing, 115 miles, at $200	23,000	
Ballasting, 40 miles, at $1,000	40,000	
	782,250	
Add 100 per cent. for increase over eastern prices	782,250	
Amount for graduation, masonry, &c		$1,564,500

SUPERSTRUCTURE.

Cross-ties, for 116.7 miles, at $1,500 per mile	175,050	
Railroad iron—75 pounds per yard—delivered at Fort Smith, for single track and sidings, for 116.7 miles, 16,945 tons, at $80 per ton	1,355,600	
Transportation of same, for 909 miles, at 5 cents per ton per mile	770,150	
Wrought-iron chairs and spikes, for 116.7 miles, at $700 per mile	81,690	
Distributing and placing iron and cross-ties, for 116.7 miles, at $1,500 per mile	175,050	
Amount for superstructure		2,558,540

EQUIPMENT.

Locomotives, 13, at $10,000	130,000	
Passenger cars, 12, at $3,000	36,000	
Baggage cars, 3, at $1,500	4,500	
Freight cars, 200, at $1,000	200,000	
Engine-houses and passenger depots	100,000	
Way stations for water and wood	100,000	
Amount for equipment		570,500
		4,693,540
For engineering and contingencies, add 10 per cent		469,354
Amount		5,162,894
Average cost per mile		44,240

Section 4.—From Campbell's Pass to the mouth of Rio Puerco of the west, 121 miles.

GRADUATION, MASONRY, ETC.

Earthwork, 3,405,230 cubic yards, at 15 cents	$510,735	
Rock-cutting, 242,000 cubic yards, at $1	242,000	
Masonry, 24,200 cubic yards, at $4	96,800	
Bridging, 1,210 feet, at $30	36,300	
Grubbing and clearing, 121 miles, at $200	24,200	
Ballasting, 10 miles, at $1,000	10,000	
	920,035	
Add 100 per cent. for increase over eastern prices	920,035	
Amount for graduation, masonry, &c		$1,840,070

SUPERSTRUCTURE.

Cross-ties, for 121 miles, at $1,800 per mile	217,800	
Railroad iron—75 pounds per yard—delivered at Fort Smith, for single track and sidings, for 121 miles, 17,659.2 tons, at $80 per ton	1,405,536	
Transportation of same, 1,027 miles, at 5 cents per ton per mile	902,178	
Wrought-iron chairs and spikes, for 121 miles, at $800 per mile	96,800	
Ditributing and placing cross-ties and rails, for 121 miles, at $1,500 per mile	181,500	
Amount for superstructure		2,803,814

EQUIPMENT.

Locomotives, 13, at $10,000	130,000	
Passenger cars, 12, at $3,000	36,000	
Baggage cars, 3, $1,500	4,500	
Freight cars, 200, at $1,000	200,000	
Engine-houses and passenger depots	100,000	
Way stations for water and wood	200,000	
Amount for equipment		670,500
		5,314,384
For engineering and contingencies, add 10 per cent		531,438
Amount		5,845,822
Average cost per mile		48,313

Section 5.—Valley of Flax river, from mouth of Rio Puerco of the west to crossing of Flax river, 35 miles.

GRADUATION, MASONRY, ETC.

Earthwork, 700,000 cubic yards, at 15 cents	$105,000	
Masonry, 8,750 cubic yards, at $4	35,000	
Bridging, 350 feet, at $30	10,500	
Ballasting, 35 miles, at $1,000	35,000	
	185,500	
Add 100 per cent. for increase over eastern prices	185,500	
Amount for graduation, masonary, &c		$371,000

SUPERSTRUCTURE.

Cross-ties, for 35 miles, at $1,500 per mile	52,500	
Railroad iron—75 pounds per yard—delivered at the Mojave village, on Rio Colorado, for single track and sidings, for 35 miles, 5,082 tons, at $110 per ton	559,020	
Transportation of same, 326 miles, at 5 cents per ton per mile	82,836	
Wrought-iron chairs and spikes, for 35 miles, at $800 per mile	28,000	
Distributing and placing cross-ties and rails, 35 miles, at $1,500 per mile	52,500	
Amount for superstructure		774,856

EQUIPMENT.

Locomotives, 4, at $10,500	42,000	
Passenger cars, 3, at $3,100	9,300	
Baggage cars, 1, at $1,600	1,600	
Freight cars, 45, at 1,100	49,500	
Engine-houses and passenger depots	30,000	
Way stations for water and wood	10,000	
Amount for equipment		142,400
		1,288,256
For engineering and contingencies, add 10 per cent		128,826
Amount		1,417,082
Average cost per mile		40,488

Section 6.—From crossing of Flax river to summit near Leroux's Spring, 81 miles.

GRADUATION, MASONRY, ETC.

Earthwork, 2,430,000 cubic yards, at 15 cents	$364,500	
Rock-cutting, 1,690,000 cubic yards, at $1	1,690,000	
Masonry, 20,500 cubic yards, at $4	82,000	
Bridging, 1,600 feet, at $30	48,000	
Grubbing and clearing, 81 miles, at $200	16,200	
	2,200,700	
Add 100 per cent. for increase over eastern prices	2,200,700	
Amount for graduation, masonry, &c.		$4,401,400

SUPERSTRUCTURE.

Cross-ties, for 81 miles, at $1,200 per mile	97,200	
Railroad iron—75 pounds per yard—delivered at the Mojave village, on Rio Colorado, for single track and sidings, for 81 miles, 11,761.2 tons, at $110 per ton	1,293,732	
Transportation of same, 232 miles, at 5 cents per ton per mile	136,430	
Wrought-iron chairs and spikes, for 81 miles, at $800 per mile	64,800	
Distributing and placing cross-ties and rails, 81 miles, at $1,500	121,500	
Amount for superstructure		1,713,662

EQUIPMENT.

Locomotives, 9, at $10,500	94,500	
Passenger cars, 8, at $3,100	24,800	
Baggage cars, 2, at $1,600	3,200	
Freight cars, 138, at $1,100	151,800	
Engine-houses and passenger depots	80,000	
Way stations for water and wood	80,000	
Amount for equipment		434,300
		6,549,362
For engineering and contingencies, add 10 per cent.		654,936
Amount		7,204,298
Average cost per mile		88,942

Section 7.—From summit near Leroux's Spring to Aztec Pass, 87 miles.

GRADUATION, MASONRY, ETC.

Earthwork, 4,105,851 cubic yards, at 15 cents	$615,878	
Rock-cutting, 1,878,709 cubic yards, at $1	1,878,709	
Masonry, 24,000 cubic yards, at $4	96,000	
Bridging, 900 feet, at $30	27,000	
Grubbing and clearing, 80 miles, at $200	16,000	
Ballasting, 7 miles, at $1,000	7,000	
	2,640,587	
Add 100 per cent. for increase over eastern prices	2,640,587	
Amount for graduation, masonry &c		$5,281,174

SUPERSTRUCTURE.

Cross-ties, for 87 miles, at $1,200 per mile	104,400	
Railroad iron—75 pounds per yard—delivered at Mojave village, on Rio Colorado, for single track and sidings, for 87 miles, 12,632.4 tons, at $110 per ton	1,389,564	
Transportation of same, 148 miles, at 5 cents per ton per mile	93,480	
Wrought-iron chairs and spikes, for 87 miles, at $800 per mile	69,600	
Distributing and placing cross-ties and rails, 87 miles, at $1,500 per mile	130,500	
Amount for superstructure		1,787,544

EQUIPMENT.

Locomotives, 10, at $10,500	105,000	
Passenger cars, 9, at $3,100	27,900	
Baggage cars, 2, at $1,600	3,200	
Freight cars, 148, at 1,100	162,800	
Engine-houses and passenger depots	90,000	
Way stations for water and wood	90,000	
Amount for equipment		478,900
		7,547,618
For engineering and contingencies, add 10 per cent		754,762
Amount		8,302,380
Average cost per mile		95,200

Section 8.—From Aztec Pass to Cross mountain, 23.3 miles.

GRADUATION, MASONRY, ETC.

Earthwork, 582,000 cubic yards, at 15 cents	$87,300	
Rock-cutting, 46,200 cubic yards, at $1	46,200	
Masonry, 5,825 cubic yards, at $4	23,300	
Bridging, 233 feet, at $30	6,990	
Grubbing and clearing, 10 miles, at $200	2,000	
Ballasting, 10 miles, at $1,000	10,000	
	175,790	
Add 100 per cent. for increase over eastern prices	175,790	
Amount for graduation, masonry, &c		$351,580

SUPERSTRUCTURE.

Cross-ties, for 23.3 miles, at $1,500 per mile	34,950	
Railroad iron—75 pounds per yard—delivered at Mojave village, on Rio Colorado, for single track and sidings, for 23.3 miles, 3,383.2 tons, at $110 per ton	372,152	
Transportation of same, 93 miles, at 5 cents per ton per mile	15,732	
Wrought-iron chairs and spikes, for 23.3 miles, at $800 per mile	18,640	
Distributing and placing cross-ties and iron, 23.3 miles, at $1,500 per mile	34,950	
Amount for superstructure		476,424

EQUIPMENT.

Locomotives, 3, at $10,500	31,500	
Passenger cars, 2, at $3,100	6,200	
Baggage cars, 1, at $1,600	1,600	
Freight cars, 40, at 1,100	44,000	
Engine-houses and passenger depots	20,000	
Way stations for water and wood	10,000	
Amount for equipment		113,300
		941,304
For engineering and contingencies, add 10 per cent		94,130
Amount		1,035,434
Average cost per mile		44,435

Section 9.—From Cross mountain to the crossing of Big Sandy, 27.5 miles.

GRADUATION, MASONRY, ETC.

Earthwork, 760,000 cubic yards, at 15 cents	$114,000	
Rock-cutting, 425,000 cubic yards, at $1	425,000	
Masonry, 8,250 cubic yards, at $4	33,000	
Bridging, 550 feet, at $30	16,500	
Grubbing and clearing, 25 miles, at $200	5,000	
Ballasting, 10 miles, at $1,000	10,000	
	603,500	
Add 100 per cent. for increase over eastern prices	603,500	
Amount for graduation, masonry, &c		$1,207,000

SUPERSTRUCTURE.

Cross-ties, for 27.5 miles, at $1,800	47,500	
Railroad iron—75 pounds per yard—delivered at Mojave village, on Rio Colorado, for single track and sidings, for 27.5 miles, 3,993 tons, at $110	439,230	
Transportation of same, 68 miles, at 5 cents per ton per mile	13,576	
Wrought-iron chairs and spikes, for 27.5 miles, at $800 per mile	22,000	
Distributing and placing cross-ties and rails, 27.5 miles, at $1,500	41,250	
Amount for superstructure		563,556

EQUIPMENT.

Locomotives, 3, at $10,500	31,500	
Passenger cars, 3, at $3,100	9,300	
Baggage cars, 1, at $1,600	1,600	
Freight cars, 47, at $1,100	51,700	
Engine-houses and passenger depots	25,000	
Way stations for water and wood	50,000	
Amount for equipment		169,100
		1,939,656
For engineering and contingencies, add 10 per cent		193,966
Amount		2,133,622
Average cost per mile		77,583

Section 10.—*From crossing of Big Sandy to crossing of Rio Colorado*, 53.7 *miles.*

GRADUATION, MASONRY, ETC.

Earthwork, 1,350,000 cubic yards, at 15 cents	$202,500	
Rock-cutting, 27,000 cubic yards, at $1	27,000	
Masonry, 10,800 cubic yards, at $4	43,200	
Bridges, 537 feet, at $30	16,110	
Grubbing and clearing, 53.7 miles, at $200	10,740	
	299,550	
Add 100 per cent. for increase over eastern prices	299,550	
Amount for graduation, masonry, &c		$599,100

SUPERSTRUCTURE.

Cross-ties, for 53.7 miles, at $2,000 per mile	107,400	
Railroad iron—75 pounds per yard—delivered at Mojave village, on Rio Colorado, for single track and sidings, for 53.7 miles, 7,797.2 tons, at $110 per ton	857,696	
Transportation of same, 27 miles, at 5 cents per ton per mile	10,526	
Wrought-iron chairs and spikes, for 53.7 miles, at $800 per mile	42,960	
Distributing and placing cross-ties and rails, 53.7 miles, at $1,500	80,550	
Amount for superstructure		1,099,132

EQUIPMENT.

Locomotives, 6, at $10,500	63,000	
Passenger cars, 5, at $3,100	15,500	
Baggage cars, 2, at $1,600	3,200	
Freight cars, 91, at $1,100	100,100	
Engine-houses and passenger depots	50,000	
Way stations for water and wood	200,000	
Amount for equipment		431,800
		2,130,032
For engineering and contingencies, add 20 per cent		426,006
Amount		2,556,038
Average cost per mile		47,600

Section 11.—*From the crossing of Rio Colorado to Soda Lake,* 96.8 *miles.*

GRADUATION, MASONRY, ETC.

Earthwork, (grading,) 1,716,000 cubic yards, at 15 cents	$257,400	
Earthwork, (embankment through sandy soil,) 700,000 cubic yards, at 25 cents	175,000	
Rock-cutting, 60,000 cubic yards, at $1	60,000	
Masonry, 37,000 cubic yards, at $4	148,000	
Bridges, 800 feet, at $40	32,000	
Bridges, 600 feet, at $30	18,000	
	690,400	
Add 100 per cent. for increase over eastern prices	690,400	
Amount for graduation, masonry, &c		1,380,800

SUPERSTRUCTURE.

Cross-ties, for 96.8 miles, at $2,000 per mile	193,600	
Railroad iron—75 lbs. per yard—delivered at Mojave village, on Rio Colorado, for single track and sidings, for 96.8 miles, 14,055 tons, at $110 per ton	1,556,090	
Transportation of same, 48 miles, at 5 cents per ton per mile	33,732	
Wrought-iron chairs and spikes, for 96.8 miles, at $800 per mile	77,440	
Distributing and placing cross-ties and rails, for 96.8 miles, at $1,500 per mile	145,200	
Amount for superstructure		2,006,062

EQUIPMENT.

Locomotives, 11, at $10,500	115,500	
Passenger cars, 10, at 3,100	31,000	
Baggage cars, 3, at 1,600	4,800	
Freight cars, 164, at 1,100	180,400	
Engine-houses and passenger depots	100,000	
Way stations for water and wood	300,000	
Amount for equipment		731,700
		4,118,562
For engineering and contingencies, add 20 per cent		823,712
Amount		4,941,274
Average cost per mile		51,057